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ELECTRICAL ENGINEERING

DECEMBER 1954

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ELECTRICAL ENGINEERING

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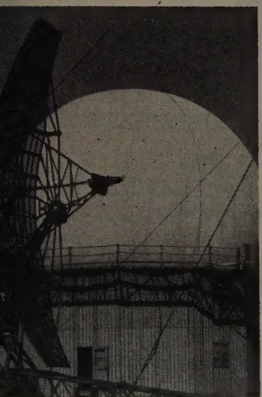

The Cover: Two versions of a powerful new radar height-finder being manufactured by the General Electric Company, Syracuse, N. Y., for the U. S. Air Force. Unit at left is mobile. Radome structure, center, houses the radar in Arctic climates. Its shape is maintained by 1/2 pound air pressure. See page 1137.

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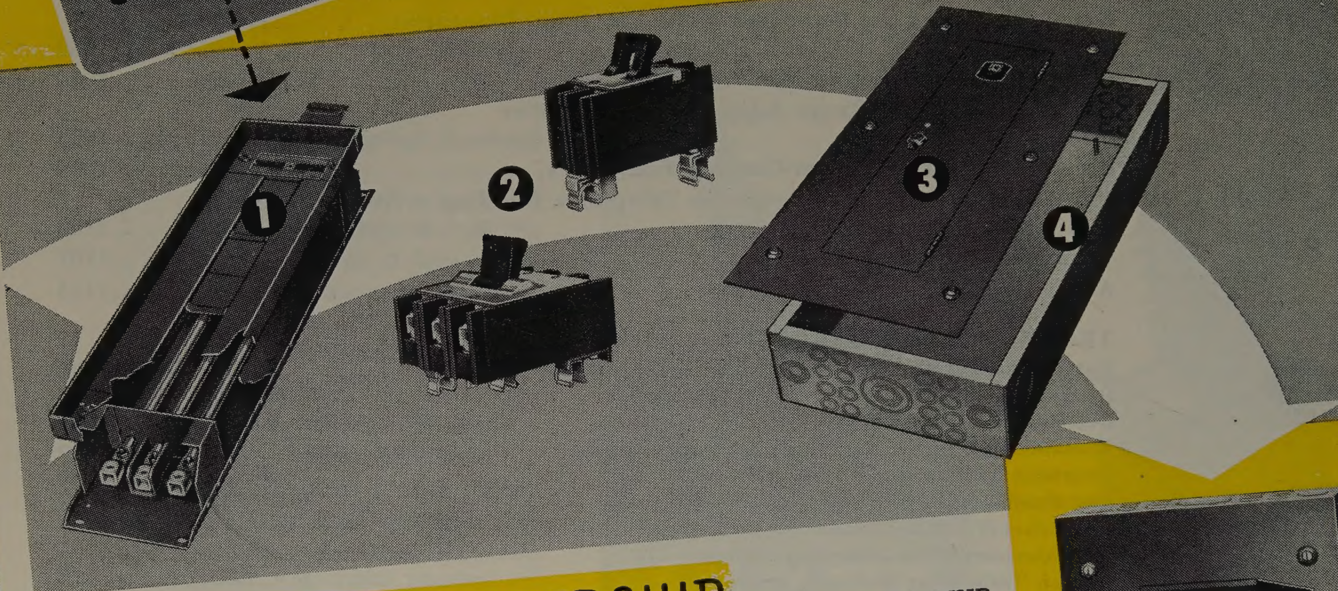

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HIGHLIGHTS........

Ten Founding Fathers of the Electrical Sciences. Joseph Henry made three important electrical contributions in the fields of electromagnetism and telegraphy. However, as he was hesitant in publishing his observations he lost priority on several of his most important discoveries (*pp. 1072–3*).

The Institute—Its Problems. Key statistics are given to show the magnitude of growth in AIEE membership and services. President Monteith reviews the financial problem involved in the changes, and the present action that is being taken by the Board in this matter (*pp. 1055–6*).

An Electrifying Future. It is suggested that the advancement of the theory and practice of electrical engineering and allied arts and sciences can be aided by the implementation of a 5-point program discussed here (*pp. 1064–8*).

Organization and Management of an Atomic Power Study. Even the learning and appraisal stage of nuclear fuel in the power industry is costly. The approach made to the problem by one of the four original industrial teams is discussed in some detail (*pp. 1068–71*).

Winter General Meeting. The program of the technical sessions and activities for the Winter General Meeting, which will be held in New York, N. Y., January 31–February 4, 1955, is presented (*p. 1124*).

AIEE Fellows. A biographical sketch of an AIEE member who recently was elected to the grade of Fellow in the Institute is given (*p. 1133*).

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Light's Diamond Jubilee and the Engineer. The Electrical Era was ushered in with the names of many great men who have aided in its progress. A review is given of those men whose contributions—in such fields as electric light and power, telephone and electrical communication, radio and television, education or manufacturing—have won for them the Edison Medal (*pp. 1057–62*).

480 Wye/277-Volt Power System in Telephone Building in Menands, N. Y. Whether the higher voltage system is called 480 wye/277 or 460 wye/265 volts, it is the same system and has the same voltage spread. Such installations are increasingly being used in many modern commercial buildings (*pp. 1100–05*).

A New Electrical Hygrometer. The control of atmospheric conditions in many industries and homes has become an important factor. The device described is reliable, simple, and a means whereby relative humidity can be controlled between the limits of 30 to 100 per cent (*pp. 1083–7*).

Demonstration of the Principle of the Ultrasonic Flowmeter. The new flowmeter is the result of a search for a simple and accurate method for making measurements of liquid flow. It is of very practical value in the measurement of water intake to hydroelectric turbines (*pp. 1082–4*).

Aircraft Switch Testing. The dynamic constantly changing nature of the aircraft problem is the principal factor causing the variance between qualities desired and achieved. After a discussion of the various factors involved in switch evaluation, recommendations are presented (*pp. 1074–9*).

Improved Wide-Range Adjustable-Speed Drive. This drive has the high starting-torque characteristic of the series motor and requires no elaborate control equipment. The speed is essentially constant when measured between no load and full load for each setting of a control-field rheostat (*pp. 1089–91*).

Fall General Meeting Attended by More Than Two Thousand. The 1954 AIEE Fall General Meeting held in Chicago, Ill., October 11–15, 1954, was attended by 2,008 members, students, and guests. The many technical sessions covered a wide range of subjects on power systems, transportation, communication, television, rotating machinery, etc. (*pp. 1121*).

Bimonthly Publications

The bimonthly publications, *Communication and Electronics*, *Applications and Industry*, and *Power Apparatus and Systems*, contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. The publications also are available to Student members at the annual subscription rate of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

An Alpha Plotter for Point-Contact Transistors. The alpha–emitter current characteristic is of great importance in large-signal applications of point-contact transistors. Most of these applications are switching and computing circuits that utilize the inherent ability of point-contact transistors to present a negative resistance characteristic at its output terminals (*pp. 1094–8*).

Transistor Broadcast Receivers. Transistors offer various possibilities such as decreased size and weight, considerably more efficient battery operation, greater mechanical stability, and indefinite life (*pp. 1107–12*).

A Survey of Magnetic Recording. Many new developments in recording media and magnetic recording heads have been made in the past 15 years. As a result, magnetic recording is being used in many new fields today, such as for computers, instrumentation, business machines, and control mechanisms. More than 200 million dollars' worth of magnetic recording equipment and accessories were bought by the American public during the past year (*pp. 1115–8*).

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

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The Institute—Its Problems

A. C. MONTEITH
PRESIDENT AIEE

President Monteith presents a review of the financial problem that confronts the Institute, following an analysis of the financial statements of the annual report and present budget allotments. This situation arises because the increased Institute services to its members has caused a great increase in expenditures.

A. C. Monteith

I COULD have planned to tell you about some of the outstanding things the Institute is doing. This would be pleasant indeed, but I feel a compelling urgency to review at this time the most pressing problem that faces our Institute. This problem is finances—dollars and cents. During the last half century, the cost of living for practically all commodities, except electric energy, has increased more than $2^1/_2$ fold. The index of these costs in January 1913 was 42.3; whereas it is 115 today. This is on the basis of the years 1947–49 taken at par or 100. During that period of time, practically all services to members have been greatly increased; yet the dues have remained unchanged for these increased services for more than half a century.

Fortunately, we are engineers and accustomed to dealing with facts. There are four facts about our finances that you should know. I will give them to you as clearly and simply as I can.

The first fact is that during this budget year we will spend about $40,000 more than we take in. Unless we do something immediately, our Finance Committee predicts a deficit approximately double this deficit in the next budget year.

The second fact is that this situation has come upon us quite suddenly. As you can see from the financial statements in our annual reports, we went from a comfortable $82,000 surplus of income over expense as of April 1953 to a $6,000 deficit as of April 1954, which is the end of the fiscal year.

The biggest single factor contributing to this unhappy situation has been a major increase in the number of papers and pages published and the correspondingly higher publication costs. Here we find a combination of general increases in the cost of labor and materials coupled with a greatly expanded program of technical activities. Our publication policy has been broadened to meet recognized needs. For example, we are now issuing the bimonthly publications. Since their inauguration they have proved extremely popular and serve 22,490 different members compared with the service to only 2,000 different members a few years ago; however, there is no compensating increase in income since these publications do not carry advertising.

Also, it was decided recently to offer preprinting facilities for conference-type papers, which will further increase expenditures by some $15,000 to $20,000 annually. These and other expanded services are helping to swell the total deficit.

The third fact is that dues for the great bulk of our membership have remained unchanged for more than half a century. Members' dues have remained at $15 for over 50 years. The initial $10 dues for Associate Members has been in effect for 70 years.

Today, an AIEE member's dues do not pay his way. In the fiscal year ended last April, each member received $24.70 worth of services. The income per member from all Institute sources was only $24.41. Although this loss per member may appear small, our huge membership magnifies this unit loss into big dollars. Thus, each new member we add to our rolls pyramids our debt instead of helping to balance the budget.

At the same time, the cost of serving our membership has been climbing steadily. It has risen from $16.77 per member in 1922 to almost $25 today. True, we have augmented our income over the years by such expedients as increasing advertising rates and the adoption of registration fees at meetings. But, this has not offset the sharp rise in costs. Such cost increases have forced most other major societies to raise their dues—some of them even twice within 2 or 3 years—in order to stay in the black. Con-

Text of an address presented before the Fall General Meeting, Chicago, Ill., October 11–15, 1954.

trary to this, AIEE has held dues at their present level but has departed from a balanced budget.

The fourth fact is that in spite of rising costs and tremendous growth, the Institute has maintained all of its services to all of its members. In fact, down through the years, services have steadily expanded as the needs arose. This has been possible only by the most efficient and thrifty operation. Compared with operation of similar organizations, we are serving our membership with a headquarters staff as small as that possessed by any similar society and substantially smaller proportionately than most.

Our service problems have been intensified because we have grown so large. Here are some key statistics that may help you realize the magnitude of growth in membership and services:

Membership almost doubled in the 20-year period from 1922 (14,263) to 1945 (23,072). It doubled again from 1945 to 1954 (47,923). Because engineering is such a potent element in our economy today, I predict that membership in our Institute will again double in the next 15 years.

Sections have more than doubled in the last 30 years. In 1922 there were 45; today there are 105. In the next 15 years we can expect our Sections to number 130 to 140.

Student Branches have also doubled since 1922, totalling 135 today. Future rate of increase here will probably be lower than for Sections because Branches are dependent upon accredited schools.

Meetings—as a measure of service to our membership—bear special significance. In general, meetings of all types have more than doubled since 1945. For example, there were four General Meetings in 1922; currently General and District Meetings are running at about six a year.

Although our membership has increased a little more than three times since 1922, Section meetings have increased well over five times. They have increased from 393 in 1922 to 884 in 1945, and then to 1,942 meetings in 1954. In addition to the Section meetings, some 416 Subsection meetings carried the Institute to members in remote locations during 1954. This is significant because it means that today the Institute is serving its members much better at the local level than it did in 1922.

Student Branch meetings have also seen similar substantial increase. Although there was a sizable drop in such meetings from 1939 through the war years, there were approximately three times as many Branch meetings in 1954 as in 1922. In the same period, the number of Branches only doubled. Since 1945 these meetings have more than doubled (547 in 1945 to 1,117 in 1954). This again emphasizes the increased service we are giving our members.

We have also had a healthy increase in the number of Special Technical Conferences. These are services pinpointed to members with specialized interests. In the fiscal year 1954, there were 14 of these conferences, some with registrations exceeding several national and District meetings.

A mushrooming phase of our national operation is our technical activities. In 1922 we had 15 technical committees with an aggregate membership of 232. Last year, our technical operation encompassed 39 main committees and 198 subcommittees with over 3,600 members. Even so, we feel that much more is still needed in this area.

These, gentlemen, are the simple facts. The expansion of the Institute and its services in all of these directions is good. We are carrying out our primary responsibility... we are improving services to our members. But, all this costs money—much more today on a unit basis than ever before. With this handwriting on the wall, common sense tells us to lay out our plans and take specific action promptly. Your Board of Directors, therefore, is taking several steps which, I believe, you as engineers will approve:

1. Through appropriate committees we have initiated extensive studies of all expenses to see if it is possible to secure even more effective handling of our income.

2. We recently reappraised our advertising rates for *Electrical Engineering* in view of recent increases by comparable journals. As a result of this study, our advertising rates will be increased by 20 per cent on January 1, 1955. This is the second increase in recent years. It is felt that this modest increase will be acceptable to the trade and, if properly handled, our predicted deficit for next year can be held to $85,000.

3. We have from time to time talked about the necessity for reorganization. We recognize, too, the need for flexibility in any organization so that we can move into new areas or to new problems speedily and effectively.

In line with this, we recently initiated a preliminary survey to study thoroughly our over-all organization and finances from a long-range point of view. I feel that we cannot put off this matter of reorganization much longer, particularly if my prediction on membership comes true.

In this connection, your Board is considering the use of an outside management consultant. The Institute has never had the benefit of such an analysis by specialists in this field and it may prove to be an extremely valuable investment.

After all this discussion, I think you engineers appreciate the importance of taking in as much money as we spend. In the face of increased services and increased basic costs, your Board believes that the past policy of holding the line on dues might be carried too far. It might result only in reducing necessary services to our members. Your Board is operating on the principle that the present situation may call for a reasonable increase in dues rather than the curtailment of some essential service that would tend to weaken our great organization. Several years ago, the Board requested from the membership the right to change the dues. This was granted but the Board found ways and means of delaying action. I can assure you that definite conclusions will be reached only after detailed studies are completed.

I bring these facts to you so that the membership can more readily understand the problems facing the Institute today. You can rest assured your officers will continue their diligent search for new economies of operation to prevent any curtailing of services. This failing, we hope you will concur that a moderate increase in dues for 1955 is the right and proper solution to our problem.

Light's Diamond Jubilee and the Engineer

EVERETT S. LEE
FELLOW AIEE

The story of progress in electrical engineering can be written in terms of the lives of Edison Medalists, who have contributed to its advancement. In this year of celebration of Light's Diamond Jubilee, one should note with pride and satisfaction their many discoveries.

THIS is a year of celebration for the great electrical industry. It is Light's Diamond Jubilee year. The keynote is "Light for Freedom, Power for Progress." Just as freedom is enshrined in the hearts of men, so progress is written in the lives of men. And so let us speak of progress in terms of the lives of men.

Go back with me to 1706, when a boy was born in Boston who was to become a great printer, writer, patriot, diplomat, scientist, and engineer. Benjamin Franklin was his name—and of him a little girl wrote—

"Benjamin Franklin—born in Boston—he went to Philadelphia—there a young lady saw him. She smiled at him. He married her—and discovered electricity."

It was just 200 years ago that Franklin braved a violent thunderstorm with only a kite, a key, and the determination to prove that the feeble discharge of the Leyden jar was of the same nature as the powerful lightning stroke. This he did, and it won him world-wide fame. But he courted death to do it.

INDEPENDENCE—AND AFTER

AND then, later in Franklin's life came restrictions to the colonists from England, came taxation without representation, came Franklin forward with his plan for Union, came Samuel Adams, came Patrick Henry against the opposition to mobilize with his still-ringing speech—

"...What is it that gentlemen wish? What would they have? Is life so dear or peace so sweet as to be purchased at the price of chains and slavery? Forbid it, Almighty God! I know not what course others may take but as for me, give me liberty or give me death."

And then came the great Declaration of Independence, the hard struggle for independence, George Washington, Valley Forge, Yorktown, when Lord Cornwallis surrendered to bring peace, but a peace that was far from bringing complete safety and complete contentment to the United States. For to build the nation there was much to do, and the next years were to see "The Critical Period," "The Period of Darkness," and "The Westward Expansion."

1876—THE ELECTRICAL ERA

THEN, in 1876, the Electrical Era was ushered in. American life at the beginning of 1876 appears to our twentieth-century eye to have been a simple, unhurried existence. Horse cars jangled leisurely through the principal streets of the larger cities. In those conveyances businessmen of the seventies rode to work. In the wintertime passengers' feet were embedded in hay or straw for warmth.

As evening approached, lamp-lighters made their rounds through the city streets. The lamps made small yellow spots of illumination in the darkness, dotting the gloomy streets in double lines. They burned with a certain amount of flicker from air currents in the square glass chambers. A high wind was likely to extinguish them. In thrifty cities the lamps were turned out on nights of the full moon.

This was the era of the reciprocating steam engine. Wherever power in large volume was required, there the reciprocating engine was to be found. The towering engines were a fascinating spectacle of intricate parts in noisy motion.

Eighteen seventy-six was America's centennial year, and its Centennial Exposition at Philadelphia was destined to open a new gateway, on which might well have been written after the manner of Solomon: "It is the glory of God to conceal a thing; but to the honor of man to search it out." Beyond that gateway lay the Electrical Era. It was ushered in with great names.

1876—THOMAS EDISON COMES TO MENLO PARK

AWAY from the bustle of cities, picturesque in its seclusion, the hamlet of Menlo Park was, until 1876, on one of the byways of life. Then suddenly into it came a man who seemed little less than a magician and who raised it to fame among the great places of the nation.

The first intimation that the village had a newcomer was when a gabled dwelling began to rise near the railroad station. Inhabitants learned that the owner's name was Edison; and after a while they began to see him—an energetic young man of 29, with searching eyes and a ready smile. Not far from his home he erected a laboratory, two stories high and 100 feet long, built of white clapboards, with a porch across the 25-foot front. Other buildings rose about the same time—a machine shop, powerhouse, and a library-office.

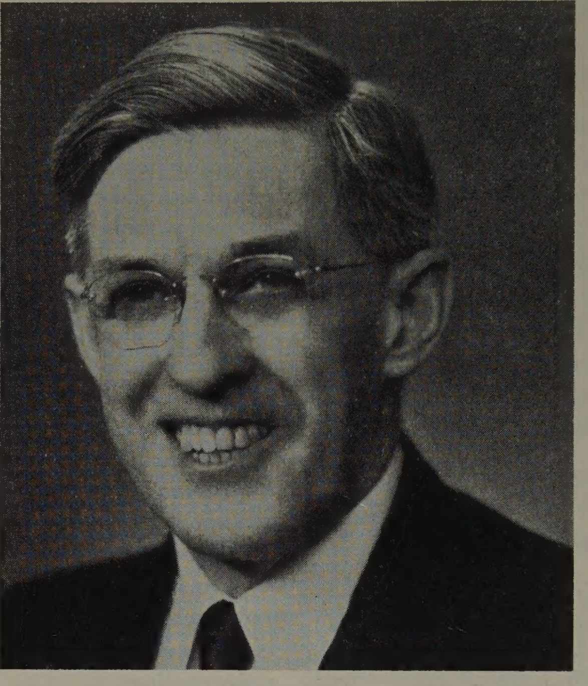
Into this small center workers began to come. The hum

Full text of an address at a meeting of the AIEE Chicago Section, October 21, 1954.

Everett S. Lee is manager, technical public relations, General Electric Company, Schenectady, N. Y. and past president of AIEE.

of enterprise arose; expectancy was in the air. Shortly after his arrival the infectious enthusiasm of the young man had caught up not only his associates, but the whole town. Menlo Park was an Edison conquest, and henceforth it was to acknowledge his residence with gratitude.

But the scientist, however great his zeal, cannot apply his ideas without practical support. Grosvenor P. Lowry, a New York lawyer of high standing, was Edison's most loyal admirer among men of influence. Jovial and good-hearted, a typical old-school barrister with Horace Greeley whiskers under his chin, he had closely followed Edison's work with the phonograph and telephone transmitter, acting as legal adviser and acquiring a tremendous faith in the ability of the young inventor. When, around 1878, public interest began to lose itself in wonder over the arc light, Lowry was one of several to think of electric lighting as an opportunity for Edison. Immediately he set about obtaining the necessary capital.



Everett S. Lee

As a result of his efforts the Edison Electric Light Company was incorporated in October 1878. Edison was now committed to experimenting with electric lighting, and he was provided with ample funds. He augmented equipment, hired more men, and put all his characteristic intensity, his great technical imagination, into the effort of producing a small-unit electric light.

Hundreds of experiments took place, and more than $40,000 was expended. Gradually a serviceable lamp filament of carbonized substance, along with an all-glass hermetically sealed bulb, were developed. Lastly, the means of obtaining and keeping a vacuum in that bulb were worked out.

Toward the end of October 1879, Edison carbonized a cotton thread. He placed it, bent in horseshoe form, inside one of his sealed glass bulbs. On the evening of October 19, this crude experimental lamp, standing upright on a table, was connected to an electric circuit. A knot of Edison workers had gathered to see what would happen. The central figure was the wizard himself. With him were Francis R. Upton, his mathematician; Charles Batchelor, his model-maker; John Kruesi, his machine-shop expert; Ludwig Boehm, his glass-blower; Francis Jehl and Martin Force, of the laboratory staff.

Current was switched on. The lamp, responding instantly, glowed with a soft light. Quickly they measured the resistance. It was 275 ohms—ample for their purpose and overwhelmingly greater than the four or five ohms of previous incandescent lamps. Then all sat down to watch the slender horseshoe of light, half expecting it to vanish. But hour after hour it continued to glow until the night was spent.

No one had eaten, no one had thought of sleep. The gray of a second dawn found them still at their vigil. That tiny glass globe with its slender filament contained their hopes of harnessing electricity—that wild, mysterious force—and setting it to work for the benefit of mankind.

About one o'clock on the second afternoon, October 21, more than 40 hours after it first received the current, Edison reached over to the rheostat and gradually increased the voltage until the filament burned out.

The spell was broken. The men leaped up with cries of jubilation. But Edison was quiet in the hour of his tremendous success. As the little lamp glowed, he had envisioned "great cities lighted from central stations" and his mind was alive with plans. But all he said, when the glow finally vanished, was "That's fine—that's fine! I think we've got it! If it can burn 40 hours, I can make it last a 100."

The successful demonstration of a solitary lamp left the spectators awestruck. Little did they realize, however, that what they had seen was to expand electrical usage literally to the confines of civilization.

Edison immediately set about supplying the tremendous demand for his new electric light. He began the first commercial manufacture of electric incandescent lamps in October of 1880, and later established shops for the manufacture of dynamos, underground conductors, sockets, fuses, switches, meters, fixtures—everything necessary for the complete system. On September 4, 1882, just 3 years after that eventful night of the first successful incandescent lamp, Edison began the operation of the first commercial central power station for incandescent electric lighting in this country. It was located at 257 Pearl Street, New York City, and supplied about 400 incandescent electric lights to a small number of customers.

THE AMERICAN ENTERPRISE SYSTEM

In that wonderful story we find all the characteristics of the American free enterprise system. It is a story told in the lives of men—men with vision to see ahead. The scientist brings forth new knowledge from nature, and the engineer forms that knowledge into products for the people to have and use. Other men invest capital to provide the equipment for research and development and design, for the buildings with machinery to produce the products to follow and to give opportunity for millions of people to

work. Lastly, we have a public which responds with enthusiasm to the new products made available to it, and a government dedicated to maintain a climate where good, free competition is the fundamental principle of achievement.

So in this year of Light's Diamond Jubilee, we recognize that electricity is one of the things which have made us the leader of the world in the production of services for mankind. Within the span of a single lifetime, electricity has been advanced into every avenue for the service of man. It has been characterized as more revolutionary for the well-being of the people of the world than any other material thing in recorded history.

EDISON THE INVENTOR

Through much of this phenomenal progress Edison continued his pioneering. The 1,097 inventions patented in his name cover nearly every phase of activity in which the electrical engineer is engaged today, even venturing into opportunities as yet little realized. These inventions include:

- 1868—Electric vote recorder, Edison's first patented invention.
- 1869–1873—Stock ticker and various telegraph systems.
- 1876—"Electric pen," forerunner of the mimeograph machine.
- 1877—Phonograph and carbon telephone transmitter.
- 1879—Incandescent electric lamp and systems of distribution, regulation, and measurement of electric current.
- 1880—Magnetic ore separator.
- 1885—System for communicating by means of wireless induction telegraphy between moving trains and railway stations; also ship-to-shore system.
- 1891—Motion picture camera.
- 1896—Fluorescope. (Edison did not patent this invention, but chose to leave it to the public domain because of its universal need in medicine and surgery.)
- 1900—Nickel-iron-alkaline storage battery.
- 1907—Universal electric motor for operating dictating machines on alternating or direct current.
- 1913—Kinetophone for talking motion pictures.
- 1914—Electric safety lanterns for miners; also the telescribe, combining the telephone and the dictating phonograph, thus permitting the recording of both sides of telephone messages.

And there were other events in the life of the great inventor which were important in the field of science and engineering:

- 1875—He discovered "etheric force," a phenomenon which a few years later was recognized as the result of electric waves in free space.
- 1880—He started operation of the first passenger electric railway in the United States, at Menlo Park, N. J.
- 1882—He began operation of the first commercial central station for incandescent lighting in the United States, in the city of New York.
- 1883—He discovered the "Edison effect," fundamental principle on which the modern science of electronics rests.
- 1931—When stricken with his final illness, Edison was pressing his investigation of the possibility of growing rubber in continental United States.

THE EDISON MEDAL

In 1904 the Edison Medal was founded by an organization of associates and friends of Thomas A. Edison, to commemorate the achievements with which Edison has been so prominently identified and to serve "as an honorable incentive to scientists, engineers, and artisans to maintain by their works the high standard of accomplishment" which he had set. The American Institute of Electrical Engineers was given the responsibility of making the awards. The medal is awarded each year by the Edison Medal Committee of AIEE to a resident in the United States of America and its dependencies, or of the Dominion of Canada, for "meritorious achievement" in electrical science or electrical engineering or the electrical arts.

Forty-three awards of the Edison Medal have been made. From those men contemporary with Edison to those men of our day, the pioneering spirit, inspiring leadership, and meritorious achievements have carried forward the brilliance of Edison's first lamp. Awards of the medal have been as follows:

1909	Elihu Thomson	1933	Arthur E. Kennelly
1910	Frank J. Sprague	1934	Willis R. Whitney
1911	George Westinghouse	1935	Lewis B. Stillwell
1912	William Stanley	1936	Alexander Dow
1913	Charles F. Brush	1937	Gano Dunn
1914	Alexander Graham Bell	1938	Dugald C. Jackson
1916	Nikola Tesla	1939	Philip Torchio
1917	John J. Carty	1940	George Ashley Campbell
1918	Benjamin G. Lamme	1941	John B. Whitehead
1919	William LeRoy Emmet	1942	Edwin Howard Armstrong
1920	Michael I. Pupin	1943	Vannevar Bush
1921	Cummings C. Chesney	1944	Ernst F. W. Alexanderson
1922	Robert A. Millikan	1945	Philip Sporn
1923	John W. Lieb	1946	Lee de Forest
1924	John W. Howell	1947	Joseph Slepian
1925	Harris J. Ryan	1948	Morris E. Leeds
1927	William D. Coolidge	1949	Karl B. McEachron
1928	Frank B. Jewett	1950	Otto B. Blackwell
1929	Charles F. Scott	1951	Charles F. Wagner
1930	Frank Conrad	1952	Vladimir K. Zworykin
1931	Edwin Wilbur Rice, Jr.	1953	John Findley Peters
1932	Bancroft Gherardi		

The early names are those who, together with Edison, ushered in the Electrical Era—Elihu Thomson, Frank Sprague, George Westinghouse, William Stanley, Charles Brush, Alexander Graham Bell.

To us in General Electric, it has always been a source of great pride that Elihu Thomson was the first Edison Medalist, for it was the great electrical manufacturing companies founded by Edison and by Thomson that were brought together by Charles A. Coffin to form the General Electric Company.

Professor Thomson, as we always called him, was also a prolific inventor, holding 692 patents. There is no better way to measure Thomson's influence on modern electricity than to reflect that there is not a single important application of the art to the daily lives of mankind that does not show the influence of his work. And just as Edison combined light and power with communication, so did Thomson. While his work was largely in the electric light and power field, there is a brass plate in one of the Philadelphia high schools which reads:

Birthplace of Wireless
In This Building in 1875
Elihu Thomson and Edwin Houston
Young Science Teachers
Sent and Received Wireless Waves
To the Distance of 100 Feet

ELECTRIC LIGHT AND POWER

EVERY branch of our great electrical industry is represented in the Edison Medalist names. In the electric light and power industry, there are:

1923	John W. Lieb	1939	Philip Torchio
1936	Alexander Dow	1945	Philip Sporn

I was privileged to know these men. John W. Lieb, in the early days of the Consolidated Edison Company, New York, was always a pioneer in the best in central station practice. He was instrumental in establishing the Electrical Testing Laboratories to maintain the quality of manufacture of electric incandescent lamps.

Alexander Dow, founder of the Detroit Edison Company, always worked with the largest steam turbine-generator units. It is most interesting that there was reported from New York that when a new turbine-generator went into operation at Detroit Edison Company on October 21, 1954, just 75 years to the day from Edison's first lamp, the nation's electrical utility industry reached 100,000,000 kw of generating capacity.

Philip Torchio, pioneer leader in central station engineering and power distribution, brought underground oil-filled cable at 132,000 volts into New York City. And Philip Sporn was the first to go to 330,000-volt transmission in this country and to announce a power plant with the installation of a steam turbine-generator unit at 4,500 psi steam pressure and 1,150 F temperature, and a boiler at 5,000 psi steam pressure.

In this connection, the recent announcement by Philadelphia Electric of a power plant with a steam turbine-generator unit at 5,000 psi steam pressure and 1,200 F temperature, and a boiler at 6,000 psi steam pressure, shows that you just can't keep the electric light and power industry down. Every advance for more efficient electricity generation and transmission is met by a succeeding advance. It is this spirit of advancement which makes Light's Diamond Jubilee a real jubilee in the electric light and power industry.

TELEPHONE AND ELECTRICAL COMMUNICATION

IN the list of names of Edison Medal winners, the communication industry is also meritoriously represented. In the field of telephone and electrical communication, there are:

1914	Alexander Graham Bell	1932	Bancroft Gherardi
1917	John J. Carty	1940	George Ashley Campbell
1920	Michael I. Pupin	1950	Otto B. Blackwell
1928	Frank B. Jewett		

If you will read the medal citations of these men, you will find the basic elements that can make an industry great. In Bell we have invention. In Jewett we have research, in Carty and Gherardi, engineering, in Pupin and Campbell, the application of mathematics and physics to the solution of problems, and in Blackwell, pioneering contributions to the art. These fundamentals of science and engineering have provided the strength which has enabled the telephone industry to give outstanding service. They are basic in any industry which hopes to live and grow.

RADIO AND TELEVISION

IN radio and television, there are five winners of the Edison Medal:

1930	Frank Conrad	1946	Lee de Forest
1942	Edwin Howard Armstrong	1952	Vladimir K. Zworykin
1944	Ernst F. W. Alexanderson		

As I sit in the living room of my home in Schenectady, and see the New York Giants and the Brooklyn Dodgers play baseball in New York City, 160 miles away, or the Cleveland Indians and the Chicago White Sox in Chicago, 800 miles away, or the University of California's Golden Bears and the University of Oklahoma's Sooners play football at Berkeley, Calif., 3,000 miles away, I marvel again and again at the contributions of the men who have made these wonders possible. And when on New Year's day this year, I saw the Rose Bowl Parade from Pasadena, Calif., on a television screen in the Park-Sheraton Hotel in New York City, in color in all its beauty, perfectly, without a blemish or an interruption, I could only think again of that wonderful quotation from Solomon: "It is the glory of God to conceal a thing; but to the honor of man to search it out."

Our scientists and our engineers have surely brought forth from God's great universe the wonders which he has put there to be made available to his people. This is truly Light's Diamond Jubilee in the radio and television industry, as also for the engineers in the electric light and power industry who have provided the power. For, while it is easier to be inspired by the wonders of radio and television, the wonder of electric light and power is also of outstanding magnitude and significance. I often think of Dr. Ernst J. Berg at the University of Illinois in 1913 before the days of radio broadcasting, who said, as he told us of Hertz and electric waves, that the great wonder is not that electricity can be propagated through space, but rather that it can be constrained to follow a wire.

EDUCATORS

THIS is also a Light's Diamond Jubilee for the educators in the electrical field, for the art and science of electrical engineering are so complex that the very highest of attainment in scientific and engineering education has been demanded and supplied from the very earliest days. Among the educators, we find:

1922	Robert A. Millikan	1938	Dugald C. Jackson
1925	Harris J. Ryan	1941	John B. Whitehead
1929	Charles F. Scott	1943	Vannevar Bush
1933	Arthur E. Kennelly		

To Robert Millikan who isolated the electron, to Harris Ryan for his outstanding work leading to 230,000-volt and 287,500-volt transmission of electric power on the Pacific Coast, to Charles Scott for polyphase power transmission and the "Scott Connection," known to every electrical engineer, Light's Diamond Jubilee owes jubilee celebration for the establishment of fundamentals so essential to our technical advances. And to Charles Scott and Dugald Jackson we owe added honor for their leadership in establishing within the engineer a realization of his position of leadership among his fellow men, not only as an engineer but also as a citizen.

To Arthur Kennelly honor is due for his application of mathematics to the solution of the circuits of electrical engineering. Dugald Jackson is honored for his contribution in the field of generation and distribution of electric power. And John Whitehead is hailed for his pioneering and development in the field of dielectric phenomena.

And all honor to Vannevar Bush, for his leadership in the development and design of mathematical calculating machines as applied to electrical and other engineering problems, and later for his eminent service to the nation when he worked with those who held the destiny of the development of the atomic bomb.

CONSTRUCTION

In the construction industry we have another great name on our list of Edison Medalists:

1937 Gano Dunn

Staunch in his leadership in great engineering works, Dunn was also steadfast in his faith in the engineering profession and the great place the engineer merits in the lives of men.

ELECTRICAL MANUFACTURING

From the great electrical manufacturing industry we also find many winners of the Edison Medal:

1909	Elihu Thomson	1930	Frank Conrad
1910	Frank J. Sprague	1931	Edwin Wilbur Rice, Jr.
1911	George Westinghouse	1934	Willis R. Whitney
1912	William Stanley	1935	Lewis B. Stillwell
1913	Charles F. Brush	1944	Ernst F. W. Alexanderson
1916	Nikola Tesla	1947	Joseph Slepian
1918	Benjamin G. Lamme	1948	Morris E. Leeds
1919	William LeRoy Emmet	1949	Karl B. McEachron
1921	Cummings C. Chesney	1951	Charles F. Wagner
1924	John W. Howell	1953	John Findley Peters
1927	William D. Coolidge		

William LeRoy Emmet was early honored for his inventions and developments of electric apparatus and prime movers. He had designed the Niagara generators for Adams Station No. 2, the first of which went on the line October 1902. When the order for these generators was placed, he said: "I can hardly give an idea of the thrill which I felt when this matter was settled. I was athirst for something big to do, and this was the biggest thing in the electrical world. Every detail of what I intended to do was in my mind, as if the plant had been running for months. I had planned the construction of the generators and had them calculated over and over again." That is the engineer.

Later Emmet was given the assignment of developing the Curtis steam turbine. It was here in the City of Chicago in 1903, at the Fisk Street Station of the Commonwealth Edison Company, that the first steam turbine-generator, 5,000-kw capacity, was installed. That steam turbine-generator required only one-tenth of the space and weighed only one-eighth as much as the reciprocating engines it replaced. The story of its building is an exciting one of engineering development and production. Today that first steam turbine-generator from Fisk is enshrined in the yard of the Schenectady Works of General Electric. On its foundation are the words, "Monument to Courage."

And that courage has continued to this day throughout the electrical manufacturing industry and the electric light and power industry. In those days 4 to 5 pounds of coal were required to produce a kilowatt-hour of electricity. Today the best performance is 3/4 of a pound. The cost of electricity to the customer has been continually decreased. The cost of electricity in 1882 to the original Pearl Street Station customers was about 24 cents per kilowatt-hour. Today the national average revenue per kilowatt-hour for residential service is 2.75 cents. The story of engineering and science behind such advances as these is surely one which every engineer can take unto himself with the greatest of pride and satisfaction in the doing of a job well done.

RESEARCH

In 1931, Edwin W. Rice, Jr., president of General Electric following Mr. Coffin, was honored for his contributions to the development of electric systems and apparatus and his encouragement of scientific research in industry. It was he who brought Dr. Willis R. Whitney to Schenectady in 1901 to establish the General Electric Research Laboratory. This was the first industrial research laboratory set aside to bring forth new knowledge from nature. And Dr. Whitney himself was later honored for his inspiring leadership in research.

Research has long been an established word in the electrical industry, and much of our celebration in Light's Diamond Jubilee rests on that foundation. Again it is progress through men.

One of the earliest research contributions to the progress of the incandescent lamp was the development of ductile tungsten by Dr. William D. Coolidge, also honored for his contributions to incandescent electric lighting and the X-ray arts. The story of ductile tungsten research is as exciting as the story of Edison and his first incandescent lamp. Later, through engineering development and design, it represented an advance from the carbon lamp of 4 lumens per watt through the early tungsten lamp of 12 lumens per watt, and on up to 20 lumens per watt with today's 500-watt lamp. And there is another story of research, development, and design by the engineers, that has brought us the fluorescent lamp, with an advance in lumens per watt to 69 in today's 8-foot slimline lamp.

Among the early incandescent lamp pioneer engineers honored was John W. Howell, for his contributions toward the development of the incandescent lamp. It was outstanding advances in lamp technology and machine production like his which brought ever-descending lamp costs. Comparing a price list of 1913 with the price of the same type lamps 40 years later in 1953, one finds the following figures:

Lamp Wattage	Cents 1913	Cents 1953
15	.35	.15
25	.35	.15
40	.35	.16
60	.45	.16
100	.80	.18

Figures such as these have really been the jubilee celebration of Light's Diamond Jubilee, for together with all of the scientific and engineering contributions in the generation, transmission, and distribution of electric power, the advances in lamp technology and manufacture have been ever continuous to give better light, better sight, at lower cost. This entire story is phenomenal, and again it is the story of men.

In the instrumentation field, Morris E. Leeds was honored for his contribution to industry through the development and production of electric precision measuring devices and controls. This brings honor to all of those who, through measurements in every branch of engineering, have made the advances possible, for, as Lord Kelvin said, if you can't measure it, your knowledge is of a meager and unsatisfactory kind.

Yes, this is a diamond jubilee year for the great electrical manufacturing industry and for the men of science and engineering in it.

And now I am going to introduce a negative note. I do not find a name among the Edison Medalists honored specifically for his contributions to electrifying the great manufacturing industries of our land. The electrification of American industry is the basis of our productivity. In the absence of a name in this field we honor those whose electrical engineering contributions to our manufacturing industry have provided our people with the manifold products they enjoy today.

THE FUTURE

And what of the future? By one prediction, the use of electricity in 1954 will be 410 billion kwh. The predicted increase in use of electricity from 1954 to 1964 is 498 billion kwh. That gives a predicted total kilowatt-hour use of electricity in 1964 of 908 billion kwh and a generated total of 1,040 billion kwh.

To meet this demand, the electrical manufacturing industry will have to produce as much electric generating equipment in the next 10 years as it has in the past 75 years since Edison's first lamp. And all the other branches of the electrical industry will have to produce accordingly. That is what Edison and his workers would have seen beyond the brilliance of their first lamp that night just 75 years ago.

Light's Diamond Jubilee year; Light for Freedom, Power for Progress. The progress to come will be made in terms of people, as in the past, and these people will be you—engineers and scientists of the great electrical industry. Others after you will enter the industry, as you once entered it, to give their lives to it and bring it to where it will be tomorrow. The Light of Freedom will have to be carried on by all of us as we live on with the peoples of the world, to be leaders and to keep ourselves strong for the conflicts which will ever arise until that light shines everywhere.

I close with the great Ruskin statement:

WE BUILD

"Therefore, as we build, let us think that we build forever. Let it not be for present delight, or for present use alone; let it be such work as our descendants will thank us for, and let us think, as we lay stone on stone, that a time is to come when these stones will be held sacred because our hands have touched them, and that men will say as they look upon the labor and wrought substance of them: 'See! This our fathers did for us!' "

"All-Transistor" Calculator Is Developed

An experimental "all-transistor" calculator, with a computing unit about one-half the size and requiring only 5 per cent as much power as a comparable vacuum tube unit, was demonstrated at International Business Machine's new Poughkeepsie, N. Y., research laboratory.

The new machine is comparable in capacity to IBM's type *604* electronic calculator, of which over 2,000 are in use. The *604* uses 1,250 vacuum tubes. While their speeds are similar, shown side by side the two machines provided a sharp contrast in size. This experimental engineering model is believed to be the first full-operative transistorized computer complete with automatic input and output.

More than 2,200 transistors are used in the machine. A number of these are of a design developed by the company's own engineers to meet the operating requirements.

Printed wiring, replacing much of the wiring normally comprising a computer's nervous system, was incorporated into the design of the new calculator to simplify production. The model contains 595 printed wiring panels, on which the transistors are mounted. Each panel, as shown, is about two-thirds the size of an IBM card.

Rural Automatization in the Swedish Telephone System

B. BJUREL

AUTOMATIZATION of the telephone plants in the rural areas of Sweden has been going on since the beginning of the 1930's. For this automatization the requirements concerning operational reliability are particularly high since the exchanges are small and unattended and located at great distances from each other.

A crossbar selector was developed in Sweden in 1919. As very satisfactory experience had been obtained with this selector, it was decided to use the crossbar selector for the automatization of rural areas. Standardized types of exchanges of unit construction of sizes 10, 20, 50, and 100 subscribers lines then were designed in 1935, the crossbar being utilized in these unit exchanges as a step-by-step switch. Of these types of unit exchanges about 1,200 were manufactured. In the beginning of the 1940's a series of new and modernized standardized types of unit exchanges were developed, the series being restricted to only 40, 60, and 100 number sizes. Further, as special complemental equipment was developed allowing the combining of a 100 number unit with another 40, 60, or 100 number unit to give a combined unit exchange of 140, 160, and 200 number capacity respectively.

The unit exchanges are of satellite type without registers and they are over junctions connected to parent exchanges which, if automatic, are provided with registers. In later years the automatic parent exchanges are crossbar exchanges designed according to a marker system developed in Sweden. Today, not fewer than 2,100 rural exchanges are automatized with unit automatic exchanges.

To enable subscriber-dialed long-distance traffic, the country has been divided into some 300 number areas, each allotted a 3- or 4-digit area code number. Each subscriber is given a 5- or 6-digit directory number.

On signing a contract for telephone subscription including an individual subscriber's line, the subscribers in Sweden have to pay an installation charge of 200 Swedish crowns, independent of the costs to the administration for connecting the individual subscriber, although in sparsely inhabited regions these costs may amount to considerable sums. The subscribers as a rule have their own individual line to the telephone exchange.

In the automatized networks the subscriber pays a fixed charge, usually amounting to 86 crowns per annum, and an additional amount the magnitude of which depends on his outgoing traffic. All subscriber-dialed traffic is charged by means of registrations on individual subscriber's meters, each registration step rating 6 öre. For calls between subscribers connected to the same exchange only one registration is made on the meter. Other calls within the same number area cause a new registration on the meter every sixth minute. Calls between different number areas cause a more frequent repetition of the registrations, for instance, every twenty-fourth second for distances between 45–90 km, and every twelfth second for distances between 180–270 km.

Table I. Maintenance Times for Rural Unit Automatic Exchanges

Type of Unit Exchange	Number of Visits per Year for Fault Clearance	Number of Hours for Maintenance per Year Including Traveling: For Direct Fault Clearing	For Preventive Maintenance	In Conjunction with Other Visits	Total	Per Connected Local Line (10 Per Cent Vacancies)
40	5	5.1	23	1	29.1	0.8
60	8	8.3	29	1.5	38.8	0.7
100	13	13	40	2.5	55.5	0.6

In the unit automatic exchanges the subscribers' lines are connected to finder switches and final selectors. Between these switching stages, discriminating selectors are provided over which outgoing calls may be connected either to an idle junction for outgoing traffic or to a final selector in the caller's own exchange. A preselecting stage is provided for routing incoming calls to the final selectors.

For reasons of standardization, each type of unit exchange is provided with fixed numbers of switches. The different control relay sets are made easily removable from the unit racks and are provided with plugs for insertion in jacks in the racks.

The rural exchanges are housed in standardized huts, which are prefabricated and delivered ready for assembly at the site of the exchange. At present the working times for construction of unit automatic exchanges are as follows: the 40 number unit requires 1 or 2 working days, the 60 number unit requires 2 or 3 working days, and the 100 number unit requires 3 or 4 working days. Average values for the time required for the maintenance of unit automatic exchanges are stated in Table I.

CONCLUSIONS

THE crossbar selector has rendered possible great operating reliability which is an indispensable requirement in connection with the automatization of unattended exchanges.

By far-reaching standardization of the type of exchange, huts, and assembling methods, the cost of the plant could be kept down.

For the subscribers in rural Sweden the telephone automatization has resulted in decreased telephone rates for subscriber-dialed long-distance traffic and generally improved telephone service.

Digest of paper **54-424,** "Rural Automatization in the Swedish Telephone System," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Communication and Electronics*, November 1954, pages 552–61.

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An Electrifying Future

W. V. O'BRIEN

Five ways to advance the electrical engineering profession are suggested: recognizing that the greatest security is in opportunity; building an economically sound engineering technology; broadening the engineers' scope of activities; helping establish the true role of the sales engineer; and building public relations consistent with the dignity of the profession.

THOSE of you in this room who have been exposed to the headlines made by Senator McCarthy during the last few years, and that should be an all-inclusive reference, are no doubt also aware that, with all the references to the Fifth Amendment and constitutional rights, Senator McCarthy has certainly helped to arouse a new public interest in the U. S. Constitution. And while I appreciate that it is political dynamite to take any stand on Senator McCarthy, I think we can safely agree that, at least in this respect, a good purpose has been served.

Certainly, it has been a reminder of a very great and thoughtful document; and my purpose in mentioning this today is to suggest that in your own American Institute of Electrical Engineers, you have another Constitution that deserves to be looked at, particularly as a reminder of purposeful direction.

You may recognize the following words of your Constitution. They are part of Article I, and they read: "Its object shall be the advancement of the theory and practice of Electrical Engineering and of the allied Arts and Sciences."

No one would question this simple expression of objective. But the real question, and the one I should like to discuss with you today, is how we can bring full meaning to these words. This is indeed a big order, and one that can best be filled if we keep in mind a basic concept—namely, that the advancement of electrical engineering is a personal thing, based primarily upon individual attitudes and individual actions. By adopting this concept, we will give full rather than narrow meaning to our stated objectives.

This also requires that the advancement of electrical engineering be accepted not only as an objective, but as a responsibility of the electrical engineer. It recognizes that no business is out to buy mass engineering, and at the same time it means that personal doing is the best and most direct road to personal satisfaction.

With this basic ground rule in mind, I would like to suggest five paths by which we can make Article I of your Constitution a living, dynamic statement of purpose. And, in fact, I might better define these five things as superhighways rather than paths, for they will certainly provide a more comfortable, more satisfying, and faster trip towards the advancement of the electrical engineering profession.

The first and perhaps most important highway, then, is the recognition that our greatest security is actually the security of opportunity. This does not overlook the need for adequate pay, for social security, for pleasant working conditions, and many of the perquisites that have not become commonplace throughout much of industry. It does, however, call for viewing them in their proper perspective. Thus, most of our present-day perquisites can be classified in the same category with a good personal insurance plan that provides basic security, and serves as a valuable anchor point from which we can strike out more boldly.

The security of opportunity, is of course, a more dynamic thing, and one that has tremendous meaning to every man in this room.

What *are* these opportunities? Where do we find them? How can they be expressed? Well, we might look first at the Gross National Product, an accepted measure of the value of the nation's goods and services—and a good index to our opportunities in a rather broad sense. Adjusted to 1954 dollars to remove the inflation factor, we can note, for example, that just 10 years from now the Gross National Product is forecast for 490 billion dollars, or 123 billion dollars greater than last year's figure. This won't be a straight-line climb, of course, nor is it the only indicator of the opportunities that lie ahead.

Let's consider another yardstick that is more directly associated with our profession—the growth of the electrical manufacturing industry's share in the Gross National Product. In 1925, this industry enjoyed about 1.75 per cent of the total Gross National Product, while in 1952 this had grown to 4.25 per cent of the total. And assuming no acceleration, just a continuation of the constant increase, the electrical manufacturing industry by 1964 will account for 6 per cent of the Gross National Product.

As exciting as are these prospects, I should make it clear that those of us in the electric-equipment manufacturing business hold no exclusive rights to future growth and development. In fact, if any conclusion emerges clearly, it is that electrical growth and the growth of the electrical engineering profession can be achieved only through the close integration and co-operation of all components—the electrical utility, the electric equipment manufacturer, the industrial user of electric power, and so on. Reduced to simple terms, this means, for example, that our plans at General Electric depend considerably

Full text of an address presented at the AIEE Middle Eastern District Meeting, Reading, Pa., October 5–7, 1954.

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upon those made by the electrical utility; and the utility, in turn, must plan according to the wants of the plants and people it serves. These interdependent relationships assume a high degree of importance, not only in the realization of electrical growth, but also in three major by-products of this electrical growth: a more secure nation; a more productive nation; and a constantly increasing standard of living, from which all of us gain.

Our research men have added further validation to these opportunities in terms of total sales of electric energy across the nation. In 1954, total kilowatt-hour sales will amount to some 411.5 billions. But 10 years from now, this figure, they estimate, will reach some 900 billion kilowatt-hours, or more than double the present figure.

W. V. O'Brien

This staggering total, bear in mind, is not the result of some fanciful thinking, but is derived from the most objective studies we know how to make. In fact, to some of us, this total represents too conservative an outlook. For one thing, it does not and cannot reflect the use of electric equipments that are now only on the horizon or beyond. Rather, it is based upon the use of known products and known technologies. And for another thing, history has shown that our friends in market research are often too conservative.

To give you some idea of where these 900 billion kilowatt-hours may be used, we might look briefly at the residential, commercial, and industrial customer of tomorrow.

In the residential area alone, we can expect some 54 million electric power customers, compared to some $42^1/_2$ million today. And by 1964, annual residential use of electricity will average more than 5,000 kilowatt-hours, more than twice the present average annual usage. In this electrifying future, residential customers will enjoy levels of lighting that will make many of today's homes seem like dim reminders of the past. In the appliance field, we will witness the widespread use of wall-mounted refrigerators, bringing about an entirely new concept of convenience, and using thin-wall vacuum insulation, ten times more efficient than other types in use. Similar advances can be expected in such appliances as food freezers, washers, dryers, and electric water heaters.

New electronic ovens using high-frequency induction heating will cook frozen meats in a matter of minutes, while cooking utensils with built-in heating elements will be automatically and thermostatically controlled; and, with special insulation protecting the work surface, will be plugged in anywhere.

The fact that market saturation for some of the well-established appliances is already quite high—as is the case with refrigerators, for example—will be more than offset by new opportunities to sell dramatic product modifications and improvements.

Or take the air-conditioning field. Thanks to improvements and growth in resistance heating, room coolers, central air conditioners, and particularly the heat pump, the total weather-conditioning load will amount to some 55 billion kilowatt-hours by 1964, compared to only 3 billion today. And even television, not always recognized as a significant power consuming device, will make its mark upon the total electrical growth of 1964, with an indicated increase of 17 billion kilowatt-hours over the next decade.

The outlook for the commercial uses of electric power is no less exciting. The need for revitalizing many services in our cities will mean new electrification in such areas as street and recreational lighting, modern rapid transit systems, new sewage treatment plants, and modern water supply systems. The outlook for future growth of the commercial electric load is also present in the downtown shopping areas, and in modern office buildings which, by 1964, will use complete air conditioning, high-voltage fluorescent lighting, and modern high-speed elevators or escalators as standard practice.

The huge new shopping centers which are already beginning to dot our countryside will house as many as 60 businesses; and with well-lighted parking facilities, air conditioning, and other electric components, each of these new additions to suburban living will consume some 15 million kilowatt-hours a year.

In both city and suburbs, the nation needs more than 700,000 new well-lighted classrooms in the next five years alone—just one more signpost of opportunity in the use of electric power for the years that lie directly ahead of us.

Even closer to many of you are the growth factors in the industrial use of electric power. This involves such prospects as a 2,000-per-cent increase in the use of kilowatt-hours for mining taconite; the increasing use of titanium and zirconium, produced electrolytically; and the development of other raw materials requiring further increases in the application of electric power. Productive efficiency in older established industries will call for the increased utilization of kilowatt-hours in the development of copper, aluminum, magnesium, and other raw materials.

Or take a well-established industry like paper. The

total output of paper by 1964 will double that of today, with a corresponding 100-per-cent increase in electric power used. And in rubber, to cite another example, the increased use of heating extruders and ovens will account for some 6 billion kilowatt-hours in 1964.

In many areas, automation, or continuous automatic production, will play a vital part in the continuing electrification of industry, and the increasing amount of horsepower per worker, with well over 90 per cent of that power being electric by 1964.

I have cited only a few highlights of the prospects for electrical growth. The doubling of the electric load in the next 10 years would seem to justify the enthusiasm and interest of anyone connected with the electrical industry. To the electrical engineer, it has a particular meaning in effecting the advancement of his chosen profession.

Alongside this first highway of progress is a second one which spells out in boldface the obligation of the electrical engineer not only to help bring about this tremendous electrical growth, but to bring it about with maximum efficiency. Think of this: next year alone will see an increase of some 46 billion kilowatt-hours in total electric energy sales in the United States. Some of this growth is so nearly upon us that it reflects only the electrical engineering content of work done some time ago. But the rate at which electric power continues to grow in acceptance will depend heavily upon our ability to have it produced and used as an economically justified source of energy—whether it be for light, for heat, or for power.

We may just as well face it—the electrical engineering profession is the key to the kind of electrical future we are discussing. To mention the opportunities that lie ahead, without at the same time pledging ourselves to the economical attainment of engineering technology, would do justice neither to the welfare of the nation nor the welfare of the electrical engineering profession.

This, too, is a job for all of us who have a stake in the production and use of electric power and electrically powered goods. The inseparable nature of economics and electrical engineering has its beginnings in the curricula of our schools and colleges. It becomes more meaningful in the industrial plant, including the plant of the electric equipment manufacturer, and in the engineering planning that must go into every branch of our great communications and electrical utility systems.

In every case, the importance of economically sound technology is such that we might well consider a kind of Hippocratic oath for the electrical engineering profession which would state in unmistakable terms our obligation to advance tomorrow's technology in terms of the reduced unit cost of the product.

Now then, you will recall that Article I of your Constitution includes within its statement of purpose the advancement of the allied arts and sciences, as well as the advancement of electrical engineering itself. If we are to bring full meaning to this objective, we will want to look at the obligation of the electrical engineer to broaden the scope of his activities, in both his personal and his business life. This is the third great highway that leads to the advancement of your profession. Particularly in this area, our basic concept of electrical engineering as a personal thing assumes great importance.

The responsibilities of the engineer to society have been debated long and arduously over the years. You are familiar with the school of thought which holds, on one hand, that the engineer or pure scientist should not be held accountable for what mankind does with the fruits of his labor; and you certainly have heard plenty from the opposite school of thought, which would have you devote so much time and effort to seeing that your brain child has proper upbringing, that you would have little or no time left to develop further new ideas.

I wonder if a realistic appraisal does not suggest that neither extreme is the answer. You cannot be responsible for the universe and other things, but at the same time, you cannot afford to neglect the many ways in which you can contribute to society, and to your own advancement. From the standpoint of society, your education, experience, knowledge, and ability are all assets that are too valuable to leave untapped. The well-trained well-disciplined engineering mind has an almost unique ability to contribute to a wide area of social progress. Church groups, parent-teacher organizations, Boy Scouts, Community Chest drives—all these and many more organizations need your special ability—and if your obligations to them are a little greater than that of the average man, it is simply because you are not an average man.

To be candid, let us admit that our score in this area has been less than perfect; and let us at the same time recognize that this obligation is not just to society, but to the advancement of the profession as well. The broadening influence of extracurricular activities can contribute immeasurably to both our prestige and our personal satisfaction.

The parallel in our business lives should be clear. Not long ago, the electrical engineer was generally limited to either the communications field, to machinery design, or to system design. What a change we have seen! Nowadays, the electrical engineer has opportunities in electronics, nucleonics, appliances, lighting, system design, cybernetics, and dozens of other areas. As a matter of fact, the electrical engineer today has a prominent role in all the better publicized scientific and engineering activities.

Today, too, the electrical engineer recognizes opportunities for further broadening and growth, through a knowledge of marketing, finance, manufacturing, management, and other fields which bring him new-found recognition.

In this connection, it is worth noting that the personal approach to electrical engineering does *not* suggest that we "go it alone." Rather, it means the acceptance of personal responsibility for progress, including progress through teamwork that can broaden our knowledge and understanding. The lonely engineering hermit may provide an interesting approach to character study, providing someone discovers him, but at best, he will more often than not restrict the progress of both himself and his chosen field of endeavor.

By contrast, as a fine example of team play, is your own

American Institute of Electrical Engineers. Now grown to almost 50,000 members, the AIEE serves as an invaluable medium for broadening engineering knowledge in a very real sense. How is this done? Through contacts with electrical engineers in your own field and in other areas; in your industry and other industries, and through social as well as business relationships.

Now if you have been keeping score, you may have noted that we have discussed three highways leading to the advancement of electrical engineering, and we still have two major roads to build. Well, with your experience in the Pennsylvania Turnpike, and ours with the New York Thruway, this shouldn't be too difficult a task.

Actually, the fourth highway is a new and important responsibility—the responsibility for helping to establish the sales engineer as an integral part of engineering achievement. Believe it or not, we still run across those people who lack a thorough understanding of the sales engineer, and of the invaluable part he plays in the sale of electrical ideas. The producer-goods sales engineer is a well-trained well-rounded man, whose influence on our future well-being deserves the best support we know how to give him. Stepping out of my role for the moment, and into my position as general manager of our General Electric Apparatus Sales Division, let me give you a brief blueprint of what we are shooting for in today's sales engineer: not just a sound engineering background, but the perseverance of a newspaper reporter, the wisdom of an elder statesman, the tact of a diplomat, the enthusiasm of a teenager, the patience of a school teacher, and the broad shoulders of a country doctor.

The sales engineer is an important communications agent in our profession. To sell is first to inform, and in this role, armed with the background of economically sound technology, the sales engineer can today carry both heavy and important responsibilities for his profession.

During a recent conference with college placement officers, I was shocked to learn, despite all this, that we still have a big job to do in promoting a better understanding of the sales engineer, particularly by engineering school instructors and professors. Through your student chapters, and through contacts with college placement officers, you, gentlemen, can perform a valuable service in helping to overcome this problem.

So, let us consider this as the start of one more highway construction job, and approach the last of our five roads of advancement for electrical engineering. This one we might call the public relations turnpike, and it embraces a large area where we must continually weigh the dignity of our profession on one hand, with the need for good public relations on the other. The dangers of lost prestige and lost dignity are well known to you. The lawyers have had their problems with ambulance chasers, and the psychiatrists have had to reckon with "quackery" from time to time.

Despite such problems, these well-recognized professions, like yours, have maintained a high level of professional dignity. Certainly, the legal profession does not crassly advertise its wares, nor can we find a physician who uses a sandwich man to advertise low-cost incisions.

And at the same time, they do have well prescribed means for bringing their professions to the fore. In law, this is accomplished through bar meetings and through organizations like the Legal Aid Society. In medicine, it is accomplished through the American Medical Association or to cite a most recent example, by means of the new smash television program, "Medic," which carries the endorsement of the Los Angeles County Medical Association.

In the case of the electrical engineering profession, I am a little concerned that we have not made the most of the opportunities for good public relations. We surely cannot afford to let the professional dignity blind us to the need for sound public relations and proper recognition.

We have seen novels, plays, biographies, and motion pictures about country doctors and country lawyers, but not very many about Sam Jones, electrical engineer. Now, this brings up a very pertinent point. An associate of mine recently stressed the fact that the time is long overdue for recognizing the contributions of the engineer to society. With this I would certainly concur. But I would go a step further and say that it is also our obligation as engineers to help bring about this recognition.

Part of the job we can accomplish through the broadening process I have previously discussed. A great deal more can be accomplished if we make sure that we are a little more articulate. Among ourselves, we write and speak a technical language that is both fitting and proper. But when we are writing and speaking to our wives, our families, our church groups, our chambers of commerce, and to the public at large, we have an urgent need to get our story across in terms that have real and sometimes fascinating meaning. This is a project that should not and cannot be done by interpreters, magazine editors, or others. And it is a project that will enhance rather than reduce our dignity. If there have been too few novels or articles about the electrical engineer, is this truly the fault of the public or the writers, or could it be that we have not done all we could to get our story across?

Then too, are we taking advantage of the opportunities for recognition of the electrical engineer in the newer popular sciences of cybernetics, electronics, and nucleonics? Perhaps many people would be surprised to know, for example, that in the field of nucleonics, electrical engineers constitute by far the largest single professional group.

The problem rests with us both as individuals, and as members of the many businesses that are closely concerned with the use of electric power. Let me cite a further example of the meaning of public relations.

During Hurricane Carol, both the telephone companies and the electrical utilities did a magnificent job in maintaining service and in restoring outages in record time. The telephone company emergency units, so identified, with red flags flying, roared down the road to the hard-hit areas in a cavalcade of trucks under motorcycle police escort. There was no question in the public mind about the fine—and yes—exciting job they were doing. The electrical utilities might well have shared some of this same public understanding, for their contributions were equally important, but the point is that the public was not nearly as aware of the job they were doing.

And so, I hope we can build all these highways that lead to the advancement of the electrical engineering profession: recognizing that our greatest security lies in the opportunities that lie ahead; building an economically sound engineering technology; broadening the scope of our activities; helping to establish the true role of the sales engineer; and building public relations consistent with the dignity of our profession.

Let us resolve to build superhighways of progress, not just some back-country roads; and in so doing, let us remember that the by-products of great responsibilities are great benefits that are rapid with new and higher levels of security, dignity, and tremendous personal satisfaction.

Article I: "Its object shall be the advancement of the theory and practice of Electrical Engineering and of the allied Arts and Sciences." Through the fulfillment of these purposeful words, all of us can share an electrifying future.

Organization and Management of an Atomic Power Study

T. G. LeCLAIR
FELLOW AIEE

A description is presented of the way one of the original four industrial teams, formed to determine whether practical and economic industrial uses could be found for nuclear fission, operated.

SHOULD a specific company start a new manufacturing business related to atomic energy? What will be the effect of atomic energy on a specific business at present in a competing field? When should a utility invest in the construction of nuclear power facilities? These and similar questions are of importance to management because of the far-reaching nature of atomic energy.

Atomic energy is inherently big business. The government has spent billions of dollars on its development, most of which, of course, has been for military purposes. Probably the future will bring more important uses of nuclear fission as a source of heat for electric power, but this will not come overnight. Even the learning and appraisal stage of nuclear fuel in the power industry is a costly venture. It takes organization just to obtain a sound answer as to when and how to start building a practical power plant.

HISTORY

THE Atomic Energy Act of 1946 made everything related to atomic energy practically a government monopoly. Charles A. Thomas of the Monsanto Chemical Company should be commended for having proposed to the Atomic Energy Commission in 1950 that industry be permitted to form study teams, to have access to the laboratories and the secret information where necessary in order to determine whether practical and economic industrial uses could be found for nuclear fission. As a result of this proposal, four industrial study teams were formed. They were the Monsanto Chemical–Union Electric, the Dow Chemical–Detroit Edison, the Pacific Gas and Electric–Bechtel Corporation, and the Commonwealth Edison–Public Service teams. The stated objectives in the agreements with the Atomic Energy Commission signed by the different groups were:

1. To determine the engineering feasibility of their designing, constructing, and operating a materials and power-producing reactor.
2. To examine the economic and technical aspects of building this reactor in the next few years.
3. To determine the research and development work needed, if any, before such a reactor project can be undertaken.
4. To offer recommendations in a report to the Commission concerning such a reactor project and industry's role in undertaking and carrying it out.

Each of these teams approached the problem in a somewhat different way due in part to the nature of the companies comprising the partnerships. One of these teams, the Commonwealth Edison–Public Service, handled the organization problem in the following way. This team had essentially two objectives: One was to carry out the work in the agreement with the Atomic Energy Commission as just mentioned. The other—equally important—was to develop and train men, especially those who were essentially utility men, so that when nuclear power plants were feasible they would have the background and training to design, construct, and operate such power plants.

Full text of a conference paper presented at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954.

T. G. LeClair, past president AIEE, is assistant to the vice-president, Commonwealth Edison Company, Chicago, Ill.

STARTING THE FIRST STAFF

The project was launched by assembling a list of possible candidates for the group and then selecting electrical engineers, mechanical engineers, electronics specialists, power-plant designers, and a financial specialist. In all, ten men already employed by the companies were selected and two consultants were added to complete the team.

Q CLEARANCES

Then came the task of obtaining security clearances for all of these people. Under the Atomic Energy Act, one is not permitted access to classified material nor allowed to receive and store such essential information until investigated and certified. Getting personnel cleared and a facility established takes several months. While awaiting Atomic Energy Commission approvals, work was confined to the examination and discussion of whatever unclassified material was available, including a review of the basic principles involved.

Fortunately much of the information necessary for a preliminary survey of the prospects for atomic energy was available in unclassified literature. Consequently, the time was well spent during the waiting period. The unclassified literature available today is much more valuable than it was then.

INDOCTRINATION

To make best use of both time and available information the services of a very well-qualified physicist and reactor engineer were obtained. He conducted a most thorough and enlightening course in nuclear physics and reactors for the entire group.

THE FIRST GROUP

The nucleus of the organization was set up in accordance with Atomic Energy Commission recommendations, providing a project manager, a technical director, and a project secretary. By the time clearances were approved and the offices were declared a secure facility, the team was partly organized and had been sufficiently indoctrinated in atomic theory to enter promptly into the study of the secret documents.

It would be difficult to exaggerate the help obtained at this stage from the Chicago Operations Office of Atomic Energy Commission. They might have merely said, "You can read the technical information." Instead, they provided information concerning which laboratories and which persons could be the most helpful and arranged visits to four laboratories as soon as clearances were obtained. They then arranged proper introductions and saw that the group was able to get the information necessary to get the study under way.

It was also most fortunate to have one of the great national laboratories in the territory. The Argonne National Laboratory specializes in the reactor field and has built and operated several reactors. This laboratory not only provided access to their library and research facilities, but spent many hours making available the benefits of their experience in this field.

MANAGING THE FIRST GROUP

Management of the early group was very simple. This was no doubt due to the guidance of the consultants and Commission advisors, to the fascinating nature of the work, and to the good working relationships of the personnel who were well acquainted with each other. The technical director acted as the co-ordinator to insure that all phases of the design study received attention. However, security measures and the development of security consciousness did require constant direction and diligent surveillance through many months. It was not too easy for a group of people accustomed to free exchange of information and enthusiastic discussion of engineering activities to "clam shut" all of a sudden. The business of making formally sure the person you are talking to is "Q" cleared and then discussing only that information which he has "a need to know" requires the development of new and deliberative habits to avoid conflict with very definite laws and clearly defined directives. The 1954 law has not relieved this restriction.

SECOND GROUP

Completion of the first two reports by the Commonwealth Edison–Public Service team indicated enough promise to show the need to carry on the study of other reactor designs and to develop and train additional men. It was therefore decided to return most of the first group to other activities and to train a new group. Interest in this activity was so great that choice of men was not easy. Finally 18 men were picked and given an un-

T. G. LeClair

classified 8-week training course, after which examinations were held to pick the men for the second group. It is expected that this practice of putting new talent into the group will continue, although it will be done by substituting one or two men at a time instead of by the platoon system.

REPORTS TO THE COMMISSION

This study team reported to the Commission on three possible reactor designs. Willis Gale, Commonwealth Edison Company chairman, stated that one of these designs had possibilities of making electric energy for about 1 cent per kilowatt-hour. He further stated that if the Commission felt it would be in the public interest to do so, the Company might be willing to undertake the task with a suitable division of cost between government and industry. About this time the Commission rightly decided that any co-operation between industry and government would have a broader base if more than one company took part in a possible program of construction. The original Dow–Detroit group expanded to become a team of some 28 companies. Later, the Commonwealth Edison Company joined four other companies to form the Nuclear Power Group. In the meantime, the original Commonwealth Edison–Public Service team had been reduced to one company by the merger of Public Service Company into Commonwealth Edison Company.

FORMATION OF NUCLEAR POWER GROUP

The five top executives of American Gas and Electric Service Corporation, Bechtel Corporation, Commonwealth Edison Company, Pacific Gas and Electric Company, and Union Electric Company of Missouri met and agreed that a joint study team was desirable and agreed to request formal permission of the Atomic Energy Commission for the formation of the group. They felt that the importance of this new development was so great that the basic management and policy setting should not be delegated. Therefore, the project management came under the following executive committee:

Stephen D. Bechtel	President, Bechtel Corporation
James B. Black	President, Pacific Gas and Electric Company
Willis Gale	Chairman, Commonwealth Edison Company
J. W. McAfee, Chairman	President, Union Electric Company of Missouri
Philip Sporn	President, American Gas and Electric Service Corporation

These companies proposed to the Commission the formation of a 5-company group, having as its objective the following three steps:

1. To select an electric-power-producing reactor design and to make a preliminary economic appraisal of it.
2. To prepare a complete detailed design for the construction of a nuclear power plant and to make a final evaluation of the technical practicability and economics of financing, constructing, and operating the plant so designed.
3. To prepare and submit to the Commission a proposal for the financing, construction, and operation of a nuclear power plant on the basis of such final design, and upon acceptance by Atomic Energy Commission, to proceed with the project.

After the Commission had indicated consent to formation of this study team, the first step was to select an operating committee which would be responsible for the basic design and economic estimating phase of this study. This committee is essentially responsible for recommending the type and size of reactor plants to be designed and for selecting the full time staff to carry out the work. Members of the operating committee were chosen who have responsibilities in their own companies that include decisions on engineering policy. While they do not devote full time to this project they meet at intervals of 4 to 6 weeks to insure that the wishes of all five companies are co-ordinated and that the project runs smoothly.

STAFF ORGANIZATION AND COST DISTRIBUTION

The full-time staff selected by the operating committee is in a Chicago headquarters under the direction of a project manager. Outside consultants are used to some extent, but there are at present no laboratory experiments under the jurisdiction of the staff.

The five companies have agreed that each member of the staff will remain on the payroll of his respective company. In keeping with the principle of using the staff activity to train a substantial number of individuals, some of the men may not spend more than a year on the assignment. Further, this arrangement permits each man to maintain his full pension rights and place in his regular organization. Seniority and position in the individual companies are, however, completely subordinated to the consideration of carrying out the task at hand.

It has been found desirable to have a relatively flexible organization so that changes could be made quickly as a change is made from one type of reactor design to another, or to meet requirements if the work should need to be expanded or decreased. Some of the companies have taken top-notch present employees and made them nuclear engineers. Others have gone outside their organization to obtain highly qualified specialists in the nuclear field. This combination insures a stable working team with a frequent infusion of new ideas. In practice, selecting men is not too easy as nuclear power plant design requires work in more than 15 specialized fields, such as mechanical and electrical engineering, physics, and chemistry.

The total costs of this study group are shared equally by the partners. This is accomplished by cross billing the amounts by which partners are over or under the average.

FACILITIES AND WORKING ARRANGEMENTS

Security requirements make it necessary to provide document control, restrictions on access to the working space, and suitable protection for classified documents at all times. Consequently it was necessary to set up an office arrangement with facilities to keep such material under lock and key and to provide guard service. This

requirement would have been a greater economic burden if fewer companies were engaged in the study.

The present studies of this team are to a considerable extent devoted to the design of two types of reactors. One of these is based on the boiling reactor principle, developed by the Argonne National Laboratory. A small reactor of this design is scheduled for construction by the Laboratory as a part of the Commission's 5-year program. The other reactor being studied is the homogeneous type developed by the Oak Ridge National Laboratory, which is an expansion of the homogeneous reactor experiment now being rebuilt at Oak Ridge. For both of these designs the laboratories have been most helpful and have permitted the interested men to visit with their specialists and to see the tests and experiments being conducted by the laboratories.

Many equipment manufacturers assist by furnishing design data on the many components which go to make up a nuclear power plant. On the boiling-reactor design, for example, the General Electric Company is currently devoting about as much time to reactor component design as the Nuclear Power Group has been devoting to the over-all plant design. In other instances, manufacturers have supplied design and cost data on heat exchangers, pressure vessels, and even fuel elements. Such co-operation contributes to the entire nuclear power field as well as this study.

THE FUTURE

THE work described to date is only that included in the first step of this program; that is, the preliminary design stage. The results of this step will determine whether to go on to the second step, which is the complete detailed design; and to the third step, the construction and operation of a full-scale nuclear power plant. Obviously the organization will be expanded if and when these two steps materialize.

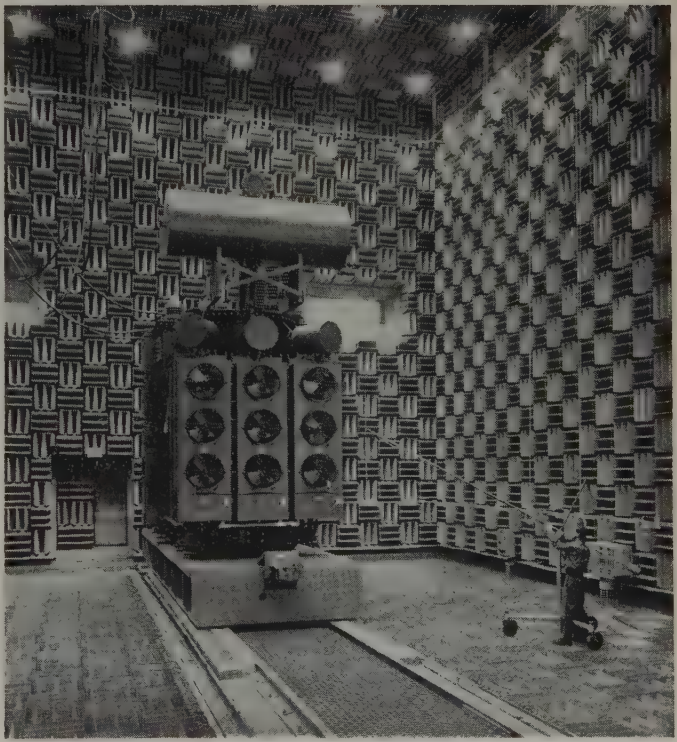
It will probably be necessary to activate a corporation for the second step and, certainly, for the third step in order to raise the necessary capital and to let contracts for research and engineering services for equipment and construction of the power plant. The type of organization necessary for the subsequent phases will depend on many questions which cannot be answered at the present time. Such a plant may make power only and may be owned by a number of partners. The financing might include some government as well as private funds. A chemical plant may or may not be required in connection with the power plant. The nature of organization for these steps will, of course, follow more nearly the conventional pattern for a power company.

A study team managed by five equal partners has its problems, especially with the five partners scattered from New York to San Francisco. However, the results obtained have been a pleasant surprise. Frequent trips and phone calls on the part of the managements have helped to keep all policy decisions unanimous. The intense interest of all the staff in this fascinating problem has speeded up the adjustments due to relocating families and changing to a completely new field of work.

The goal is still some distance away, but so far the 5-horse team has pulled smoothly through the mixture of politics and science.

New Sound Laboratory Has World's Largest Anechoic Chamber

A new $1,500,000 sound laboratory with the world's largest anechoic (without echoes) chamber was officially dedicated recently by the General Electric Company's power transformer department at Pittsfield, Mass.



It is to be used for studying the sound of power transformers. With the new facility, General Electric hopes to eliminate the problem of transformer noise. Transformers rated 500,000 kva or higher (larger than any being built today) can be tested in this laboratory.

Major part of the sound laboratory is the anechoic chamber, which is about as high as a 4-story building. More than 12,000 fiberglas wedges completely cover the floor, ceiling, and walls of the room.

Built to the specifications for a 30–40-db ambient sound level, tests have shown the sound level in the anechoic chamber to be less than 20 db. Measurements, accurate to a fraction of a decibel, will detect even the smallest improvement in transformer sound characteristics.

The anechoic chamber, besides being echoless, is also protected against radio frequencies. A total of 20,900 pounds of copper sheeting was used to line the room so that tests can also be made on transformers for radio and television interference.

IX. JOSEPH HENRY

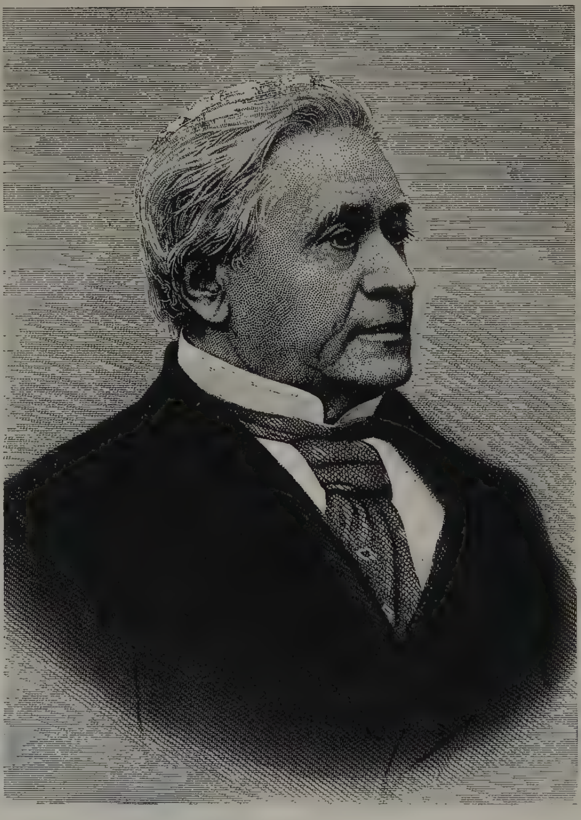
on electromagnetism and telegraphy

BERN DIBNER
FELLOW AIEE

Joseph Henry independently discovered electromagnetic induction, the self-induction of an electric surge, and the oscillatory nature of discharges; he constructed the first operative telegraph. The best known physicist of his time, he was appointed first secretary of the Smithsonian Institution in Washington, D. C., in 1845.

THE ELECTRICAL contributions of Joseph Henry were many; three were of primary importance. The first of these was the discovery of self-induction, the second was the construction of a practical electric telegraph, and the third, the determination of the oscillatory nature of lightning and the discharge from a Leyden jar.

It was at the Albany (N.Y.) Academy that Henry, without a knowledge of the experimental discoveries of Faraday, carried out experiments in electromagnetic induction, using electromagnets. In other experiments Henry transformed electric into mechanical energy by constructing an electric motor of novel design. He balanced a straight iron bar (on which an electromagnetic coil had been wound) on knife edges upon which rested trunions set in the bar's center. Below the electromagnet a bar magnet was placed so that the north poles faced in the same direction. Two batteries, one at each end of the electromagnet, were connected to their respective coils and equivalent pairs of leads terminated each coil end. When one end of the bar was depressed the coil was energized and thereupon moved up at the same time reversing the current and depressing the other coil which became energized. Thus a rocking motion was given to the bar electromagnet.



Joseph Henry

William Sturgeon in London, in 1825, improved Ampere's simple magnet by winding a wire carrying current about an iron, horseshoe-shaped bar. He did this by covering the iron bar with insulating varnish and winding a bare, copper helix upon it. Henry, in 1829, exhibited his improved horseshoe magnet at the Albany Academy. It was made by coating the *wire* with insulating material, thereby enabling him to wrap the coil much closer. Further, he polished the end faces of the iron magnet and added an armature to bridge the gap between these faces, thereby closing the magnetic circuit. An additional improvement consisted of winding the magnet with multiple layers of windings. Henry thereby built up two classes of magnets—those having a few turns of wires with large cross section and those having many turns of fine wires. The former he called *quantity* magnets, the latter *intensity* magnets. With these differing constructions Henry was able to demonstrate Ohm's law, which first was announced in 1827.

In another step in the study of the character of induced currents, Henry wound two coils on a common toroid form. One coil consisted of a few turns of heavy copper wire insulated with a coating of black enamel paint. The other coil was wound upon an insulating covering of the first and it consisted of many turns of fine wire. With this assembly Henry could deliver currents of high intensity (voltage) or high quantity (current) by selecting the proper relationship

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of the number of turns of the coils, thus inaugurating transformer design.

The step from scientific curiosity to engineering was made with a magnet that Henry built at Albany. This, a horseshoe magnet, was only 9½ inches high, had an iron core 2 inches square, and weighed 21 pounds. Upon this bar were wound nine coils of wire, each of 60-foot length. These coils had terminals that could be connected in series or in parallel. With current in the coils it was found that a 7-pound armature, fitted to the pole faces, could lift a weight of 650 pounds, an astonishing demonstration for that time.

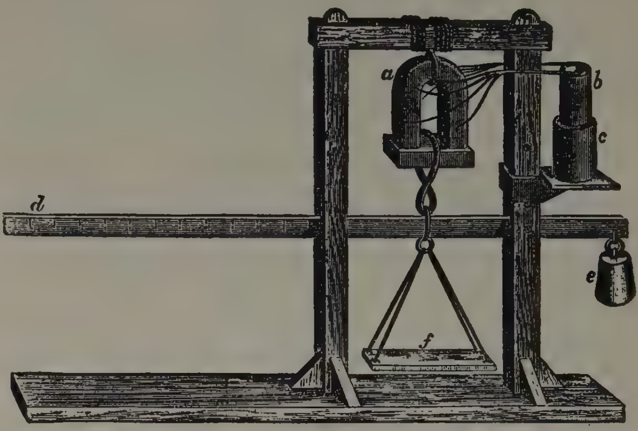
In 1832, Henry moved to Princeton University as professor of natural philosophy, the term then still used for science. Here he constructed his largest electromagnet, one capable of holding a weight of 3,600 pounds. With this large magnet Henry generated induced electric currents. He covered a piece of copper wire 30 feet long with insulating varnish and wound this about the iron armature which then was fastened to the poles. The terminals of this smaller coil were attached to a galvanometer while the terminals of the coils of the large magnet were attached to the dry plates of a voltaic battery. At a signal from Henry the plates were plunged into a vessel of dilute acid. At the instant of immersion the galvanometer needle deflected 30°, indicating the generation of an induced current in the armature coils. After an instant the needle returned to zero. Withdrawing the battery plates from the acid produced a motion of the needle in the opposite direction but of lesser intensity. In his paper Henry also announced his discovery of self-induction. This occurred when he broke a circuit consisting of a battery and a long wire, especially one wound into a coil form, whereupon there appeared a long spark at the break points. Henry believed that the long wire became charged in some manner while the current flowed; a break in the circuit caused a reaction on itself with resulting spark.

While still at Albany, Henry constructed a telegraph consisting of more than a mile of wire stretched about a room at the academy. At one end of this long circuit he placed a bar magnet, one pole of which was planted between the legs of a horseshoe magnet. When the circuit was closed the magnetic coil was energized and caused the bar magnet to shift horizontally, thus striking a bell with its farther end. A later modification caused dots to be placed on a coil of moving paper. A code of rings or dots was related to the alphabet, thereby providing a practical electric telegraph.

Henry extended the experiments of Faraday in the mutual induction of two adjacent coils to spaces between them, bordering on radio communication. He presented a paper in 1838, "On the Induction of Secondary Currents at a Distance." In these experiments Henry placed two coils, one 4 feet in diameter and a small secondary coil of many turns of fine ware, at varying distances up to 4 feet apart. He then had an observer take a second coil into an adjacent room and managed to communicate signals to him. In 1842 Henry magnetized steel needles by discharging a battery of Leyden jars into an aerial which was placed several hundred feet away from his telegraph line on the Princeton campus.

Henry studied lightning discharges by their magnetic effect on steel needles. He used the metal roof of his laboratory as an aerial by soldering a wire to it and leading this wire into the laboratory, through a magnetizing coil, and then grounding the wire in a deep well. He found that even distant lightning flashes magnetized the needles, sometimes in opposite polarity. This led him to the conclusion that lightning discharge was oscillatory in character, similar to that from Leyden jars. He also studied Leyden jar discharges by using a glass cylinder with a helical strip of tinfoil pasted both outside and inside of the cylinder thereby producing a true transformer. A needle placed in the coil

WORK AT ALBANY



Henry's apparatus for testing electromagnets: a is the magnet, b and c the adjustable voltaic cell

of the secondary became unevenly magnetized when a Leyden jar discharge was sent across the primary, again proving the oscillatory nature of the discharge.

At Princeton in 1836 Henry constructed a telegraph across the campus using two wells for the ground return. Through this circuit he sent signals from his home to his laboratory. He also adapted the telegraph receiver mechanism to act as a relay for closing a secondary circuit. When the primary electromagnet caused a counterbalanced arm to be brought down to the magnet poles, the outer end of the arm caused a wire to dip into a pool of mercury, thereby closing the secondary circuit. The relay principle found very wide use in telegraphy and in other circuit-closing mechanisms.

Henry was appointed the first secretary of the Smithsonian Institution in 1845, a position in which he established the practice of reporting meteorological changes throughout the country by telegraph. Henry was hesitant in publishing his observations and thereby lost priority on several of his most important discoveries. He applied for no patents and sought no monetary rewards. He stated: "The only reward I ever expected was the consciousness of advancing science, the pleasure of discovering new truths and the scientific reputation to which these labors would entitle me." A fire that occurred in his office at the Smithsonian in 1865 destroyed all of his early papers; otherwise, Joseph Henry, the best known physicist of his time, would be more widely known today. Meeting in Chicago in 1893, the International Congress of Electricians established the "henry" as the international unit of inductance.

Aircraft Switch Testing

T. R. STUELPNAGEL
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Factors determining switch merit such as insulation, contact operation, peak voltage transients, and switch mechanisms are considered. Simulation of inductive loads is also discussed as a means of obtaining more realistic test results.

It has been stated that the only real obstacle to push-button warfare is the design of an adequate switch. Unfortunately, aircraft switch design and application has lagged behind the needs of the industry. One of the most effective ways to shorten this lag is to learn more about switches and switching problems as the required performance and reliability are not always achieved by present aircraft switch designs. This discrepancy is not due to the difficulty of the problems involved. Equipment environment requirements as well as weight and space limitations can generally be designed to the very optimum of refinement, given sufficient time. It is the dynamic, constantly changing nature of the aircraft problem that is the principal factor in producing the variance between the qualities desired and qualities achieved. Standards that were considered impractical or impossible yesterday are achieved today, only to face even higher standards for tomorrow. The difference between production design performance and present design objectives may, therefore, be regarded as principally a phase difference, often unavoidable with such rapidly changing environmental and performance objectives. While the need for higher-performance equipment is recognized in the aircraft fields of power generation and power application, it is not always apparent that aircraft circuit interruption and closure equipment is regarded with the same degree of seriousness. This condition, of course, will correct itself in due time, but it is suggested that the present time may be a period where this phase lag between production switchgear and the anticipated requirements of aircraft design is likely to be especially large and critical. Therefore, a discussion of switch evaluation and testing techniques may be timely.

In addition to changing environmental requirements of lower pressures and higher temperatures, aircraft switch design and testing procedures are likely to be strongly affected by:

1. A critical need for greater reliability.
2. The circuit interruption transient voltage problem.

Damage from peak voltage transients that cannot be solved entirely by improved insulation poses a severe hazard to high-altitude operation and control of inductive aircraft electric equipment. It may not be practical to increase surface insulation creepage distances sufficiently to provide safe extreme-altitude operation for the several thousand-volt inductive circuit interruption transients now generated by present switch designs.[1]

RELIABILITY REQUIREMENTS

Increased reliability is needed in aircraft switchgear if it is to keep pace with aircraft advancement. Insulation test requirements are an example. For aircraft electric switches and other equipment, these insulation requirements are considerably below the insulation test requirements of either the electrical industry or the Underwriters Laboratory. The electrical industry and Underwriters Laboratory both require high-potential tests in excess of 1,000 volts rms, 60 cycles, to meet minimum safety requirements even for household equipment. Much aircraft electric equipment is tested to only 500 volts rms, 60 cycles.

High over-all system reliability requires a very high reliability of the individual components of the system. For example, if there are one hundred switches on an airplane, all of which must operate correctly to complete a military mission, then to have a probability of failure of one switch out of one hundred flights means that this hypothetical airplane must be equipped with switches that have a life expectancy of 10,000 operations without a malfunction. Testing and inspection procedure to ensure such a degree of reliability represents a considerable change from present practice.

Positive operation contacts are essential in switches where high reliability is needed. Switches that limit the travel of landing gear actuators or gun turrets are specific examples. Failure of such switches to open can result in serious mechanical damage to the airplane. The fire hazard of the resultant stalled motor must also be considered. In aircraft switches the emphasis has been placed on snap-action contact separation with little effort expended in providing positive mechanical follow-up on these snap-action mechanisms that could, in an emergency, open the contacts with the many pounds of force available in the typical operating device instead of the few ounces of force available in the typical snap-action mechanism. Snap-action contact separation may be desirable from an electrical standpoint, however, mechanical follow-up on the snap action is essential to really reliable switch operation.

INDUCTIVE CIRCUIT SWITCHING TRANSIENTS

Several thousand-volt inductive surges may result when a circuit is interrupted to inductive aircraft equipment such as solenoids, relay coils, motors, etc.[1] These voltage

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Full text of paper 54-352, "Comments on Aircraft Switch Testing," recommended by the AIEE Committee on Air Transportation and approved by the AIEE Technical Operations Committee for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

T. R. Stuelpnagel and **J. P. Dallas** are both located in Culver City, Calif.

transients in excess of 1,000 volts for 28-volt aircraft equipment appear as a severe voltage stress to the insulation of the switch, as well as the equipment generating the surge. Fig. 1 is intended to illustrate this condition. Normally the instantaneous breakdown impedance of the switch gap during circuit interruption determines the value of peak voltage generated. However, with aircraft equipment insulated and tested to only a 500-volt rms, 60-cycle, high-potential test, it often happens that the transient voltage damages insulation in the equipment or switch before it can be harmlessly dissipated in the switch gap. Measurements demonstrate that circuit opening voltage transients are as severe in 28-volt aircraft equipment circuits as in higher-voltage systems with similar equipment.

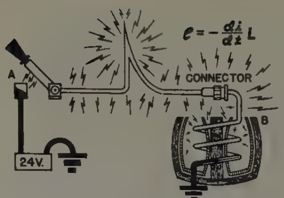

Fig. 1. Voltage stress caused by circuit interruption

Circuit interruption time may be a critical factor in aircraft switch application. Consideration of the expression for the emf of self-induction: $e = -(L\ di/dt + i\ dL/dt)$ where e = transient voltage, L = inductance, i = current, and t = time, will show that the potential voltage stress of the switch and equipment insulation is proportional to the instantaneous rate of change of current and inductance.

Therefore, it is not enough just to limit total interruption time to some reasonable figure. For example, it is commonly recognized that when the total circuit interruption time approaches a millisecond or less per ampere of interrupted load, destructive voltage transients will occur. This is a condition found only in the gross misapplication of switchgear such as the ill-considered use of vacuum, oil, or solid dielectrics in the gap of rapid action switches. However, a much more common and critical, though seldom recognized condition, is the fact that voltage transients of several thousand volts may occur in a circuit with a total interruption time of many milliseconds per ampere.

These high-voltage transients are caused by discontinuity near the end of the interruption cycle. Fig. 2 is a typical representation of voltage and current conditions during circuit interruption. It is to be noted that the sharp current discontinuity near the end of the interruption cycle produces the principal voltage rise.

This final microsecond discontinuity in a total interruption cycle of several milliseconds is the cause of an insulation puncturing spike. This is not an exceptional condition. It is the typical result of present switch and circuit design. The factors controlling the value of this transient are many. While a quantitative study has not been made, it can be stated with some certainty that in common aircraft inductive circuits, the values of inductance—as is commonly measured—and resistance are of less importance than the following three factors in determining the peak value of such transients:

1. Dielectric losses.
2. Core losses. Since such transients are of high frequency and contain little total energy, the peak value is considerably affected by both core and dielectric losses. The substitution of a laminated for a solid core has been noted to more than double the peak voltage measured.
3. The velocity and length of the switch gap during the terminal-spike forming part of the interruption cycle.

HIGH POWER SWITCH INSULATION

The insulation of primary-power switching gear raises a serious problem where high-current faults are possible. T. J. Martin and R. L. Hauter[2] call attention to the fact that phenolic materials and many other commonly used insulating materials have a tendency to burn vigorously and to contribute, extend, and reinitiate power arcs. Switchgear terminals and contact assemblies connected to main buses and/or high-capacity generator feeders can become involved in this very serious hazard. The above-mentioned discussion indicates that standard American Society for Testing Materials insulation arc resistance test methods may not be adequate to cover all aircraft conditions. Only 400-cycle 115/200-volt aircraft systems of 60 kva capacity or higher are considered in this study. The hazard arises not so much from normal circuit operation as from abnormal or accidental conditions. A misplaced piece of safety wire, loose terminal connections, floating washers, and even tools, inadvertently left near or in junction boxes, have been the cause of serious faults and battle damage. The question herein posed is whether, when such a fault occurs, the whole installation will burn up or the fault will clear itself before serious general damage results. While investigations of the extent undertaken by Martin and Hauter have not been carried out with d-c systems, preliminary information indicates that almost an identical problem exists where batteries are used to back up a 28-volt aircraft system. And, of course, with 120-volt direct current the situations described by Martin and Hauter can be realized from a normal 30-kw system without a battery.

The purpose herein is not to deal with this problem, but to analyze it and to suggest that it deserves more attention. The implication of present data is that maximum effort should be made to eliminate phenolic and other arc-supporting materials from heavy power-handling switchgear

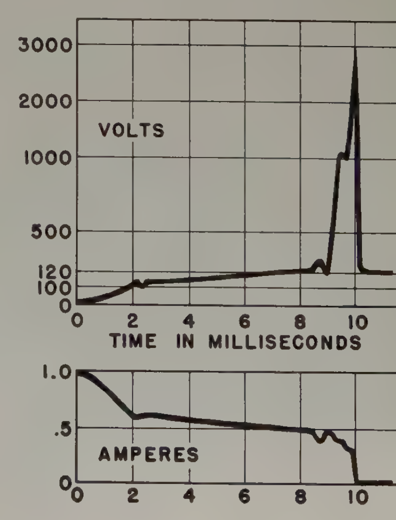

Fig. 2. Typical peak voltage transient

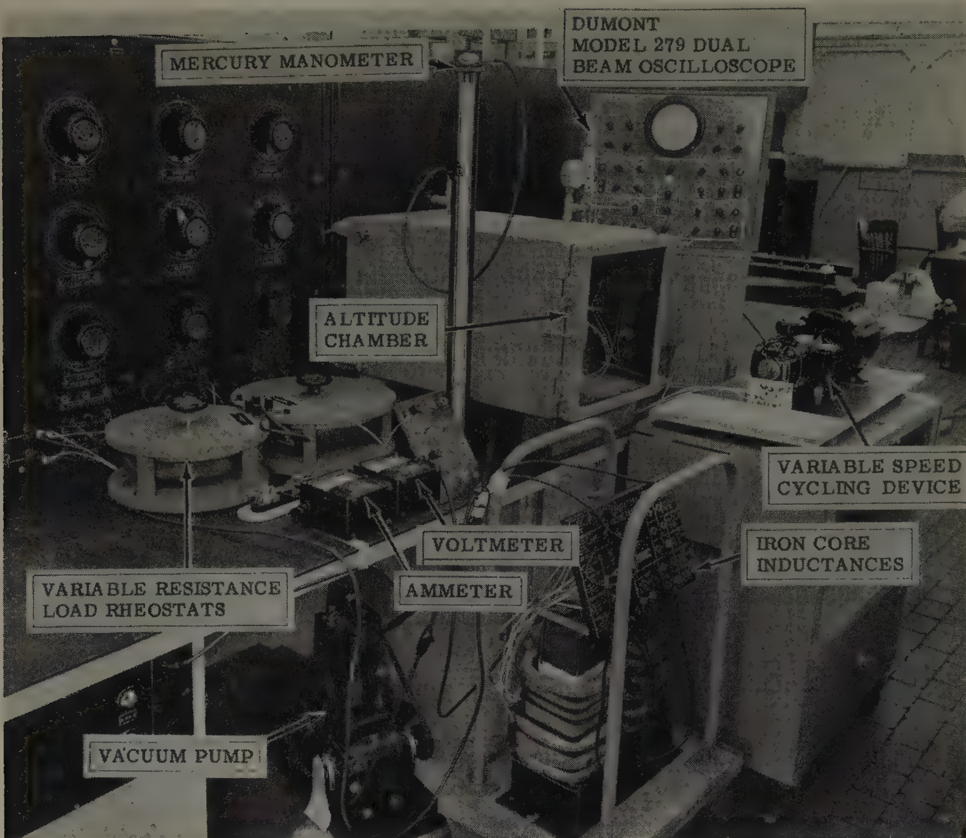

Fig. 3. Test setup for switch analysis

evaluate more than ten variables. Just as much diligence and engineering science should be used in switch testing as in tests of seemingly more complex equipment.

Aircraft Switch Evaluation. Aircraft switches should be evaluated in the test laboratory to determine these characteristics:

1. Current - interrupting capacity at specified voltage, altitude, and type of electric loads. The range of altitude conditions to be considered should be specified because some types of switches may be critical at certain altitudes while operating better at maximum altitudes or minimum pressure.
2. Current-carrying capacity should be determined at the most critical condition which is usually determined from a study of maximum ambient temperature and altitude requirements.
3. Peak interruption transient voltage resulting from the interruption of specified aircraft inductive loads should be determined so that, if necessary, provisions can be made to prevent damage to insulation of the switch itself and to equipment on the airplane.
4. Life expectancy of the switch should be determined at rated current and specified operating conditions.

and to substitute glass-bonded mica and other arc-resisting and nontracking insulators.[3]

SWITCH TESTING

Rating a Given Switch for Aircraft Application. The most difficult thing about this problem is that it looks deceptively simple. This impression is far from correct because electrical switching is a complex subject. Perhaps no other basic electrical engineering science is so little documented, yet troubled with so many variables, as is circuit interruption.

Not uncommon approaches to switch testing might be described as follows:

1. Establish a rating for this switch. Test it, but not to destruction, and have the answer by tomorrow.
2. A lot of data on the performance of switches are unnecessary as long as they meet the specification.
3. A switch test should be a life test of a few switches with a given set of conditions.

Actually a life test, or a test to the minimum requirements in a specification, constitutes only a small part of proper switch evaluation. Furthermore, the results from a life test alone have limited application unless the basic switch characteristics have also been determined. The tail-end testing used in most switch evaluation has long since been discarded in other fields. It remains in switch testing because a switch is often thought of as being so simple that an organized scientific approach is not necessary. Exactly the reverse is true; an aircraft switch test must control and

Variable Factors Affecting Switch Testing. In a typical switch test there are 14 factors or conditions that must be either controlled or measured if the test is to be conclusive. The seven conditions that must be controlled are:

1. Current.
2. Voltage.
3. Type of load.
4. Atmosphere in which switch operates.
5. Frequency of switch operation.
6. Mode of operation, that is, the speed and pressure with which the operating element of the switch is moved.
7. Type of current: alternating, frequency, direct and supply system regulation under the specified load.

The other seven factors are characteristics of the switch. These factors may be dependent upon the foregoing conditions but should be monitored throughout the tests:

8. Arc time.
9. Peak voltage during interruption cycle measured across the switch gap with a recording device having an input circuit impedance of at least 1 megohm and a frequency response of 1 mc.

10. Contact heating.
11. Arc energy.
12. Speed of contact separation.
13. Contact pressure.
14. Contact separating force.

The tendency in switch testing is to neglect some of the variables completely and to discount the importance of others. For example, arc time and its relation to maximum interrupting capacity is not usually evaluated in a switch test. Peak voltage, arc energy, and mode of operation are other variables that may seem unimportant but actually must be known or controlled in order to make a valid switch test.

Three Phases of Switch Evaluation. The test of a switch may be divided into three phases:

1. Mechanical evaluation of the switch mechanism and the contact assembly.
2. Electric test of switch to determine current-carrying and interruption capacity as functions of the specified electrical supply, environment conditions, and load.
3. Life test of switch at rated current and specified load.

It is to be noted that conditions for proper switch life tests are dependent upon the results of the foregoing tests.

The Switch Test Report. A complete aircraft switch test report should present the following data:

1. Observations, photographs, and measurements defining the mechanics of the switch.
2. At least two curves of arc time as a function of current.
3. Four curves of current-interrupting capacity as a function of various altitudes versus load.
4. One curve of current-carrying capacity showing the millivolt drop across the closed contacts as a function of current.
5. Results of life tests.

MECHANICAL EVALUATION

Before starting electrical tests on a switch, several units should be disassembled and the mechanics of the switch studied. Some general criteria for evaluating mechanical reliability are as follows:

1. General simplicity and workmanship of the unit.
2. Contact closure and separating forces should be measured and should be adequate. In general, if forces available to open and close contacts are less than one ounce they are inadequate. Analysis of these observations with respect to vibration and acceleration should be made to determine if the net contact forces are likely to be adequate under the extremes of operational environment.
3. Contacts should close with a mechanical overtravel of at least 0.010 inch. This preload provides tolerance for contact erosion.
4. The open contacts should provide a gap of at least 1/16 inch to ensure freedom from malfunctions caused by metal transfer, contact bounce, and mechanical tolerances.
5. Contact points should be securely fastened to contact arms and should have a proper thickness of contact metal to allow for anticipated erosion.
6. Nontracking arc-resistant insulation materials should be used, with special attention to the nature of the material and clearances around the contact gap and terminals where arcing and sparkover are likely to occur.
7. The melting or softening points of all materials used should be considered. In general, soft solder and plastics that soften at temperatures below 400 F should be questioned.
8. The construction of detent mechanisms should be especially noted. They are the most complicated part of a switch and consequently the most apt to fail because of mechanical wear, temperature, or production tolerances.

If there is any doubt about the mechanical ability of the switch to withstand all operating conditions and to operate the required number of cycles, a preliminary accelerated

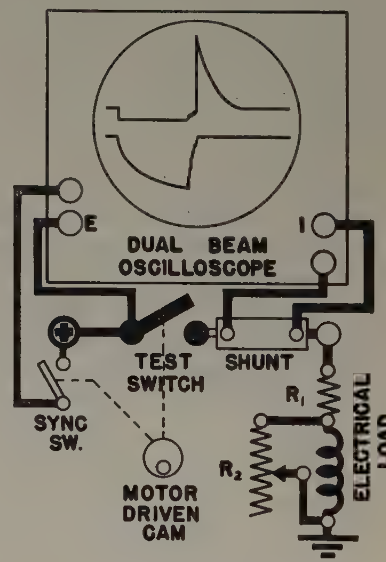

Fig. 4. Test circuit used in switch analysis

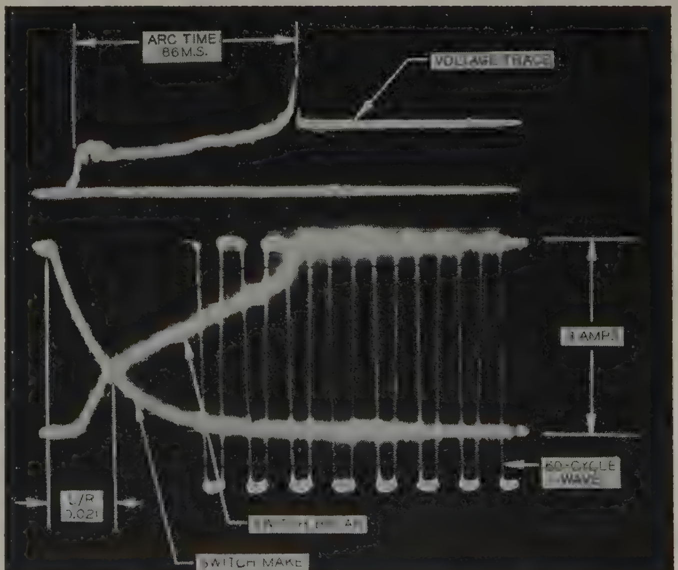

Fig. 5. Oscillogram of switch operation obtained with test setup of Figs. 3 and 4

mechanical test should be run before starting the electrical test. Time and money can be saved by eliminating unsatisfactory mechanical designs early in the test schedule.

It is the writers' opinion that aircraft switches should be tested for a mechanical life of not less than 100,000 operations, if really reliable 10,000 to 20,000 cycles of operation are to be ensured for the production item installed in an airplane.

ELECTRICAL EVALUATION

A TYPICAL assembly of switch test equipment consisting of a dual-beam oscilloscope, a pressure-controlled chamber, a resistance load bank, variable inductors, a variable-speed cycling motor, and a recording camera for the oscilloscope that includes, preferably, a Land polaroid-processing unit is shown in Fig. 3. The Land camera permits immediate evaluation of recorded transient data. These items of equipment may be arranged in a test circuit as shown in Fig. 4. A typical oscillogram resulting from such an assembly is shown in Fig. 5. One of the special advantages of this arrangement is that it presents on one oscillogram the variables of current, voltage, arc time, arc energy, peak interruption transient voltage, and load inductance-resistance ratios.

Determination of Switch Arc-Time Characteristic. One of the revealing characteristics of a switch is the variation of arc time with current. In general, as current through the switch is increased, the arc time on contact separation will also increase slowly. However, when the current approaches a critical value the arc time suddenly increases rapidly with a small increase in current until the arc sustains. Once this curve has been established for a specified set of conditons, the switch may be rated quite accurately by picking a current value below the knee of this curve. A ratio of about 75 per cent of the value determined for the knee of this arc-time versus current curve is regarded as a practical safe rated current for most aircraft switches.

It would be desirable to have arc-time versus current curves for several values of inductive loads and also for increments of altitude; however, the large combination of conditions required to obtain these curves is impractical for the typical switch test. A more realistic approach is to take only two arc-time curves and to use these as rough guides in acquiring the more important altitude characteristic curves to be obtained later. It is suggested that the two arc-time curves be taken at sea level, one curve with a resistive load and the other with an appropriate inductive load.

Determination of Switch–Altitude Characteristic. Four curves of maximum switch-interrupting capacity versus altitude, for the four following conditions, are suggested: First, a resistive load curve plotting maximum currents to 50,000 feet altitude may be run. Then, three inductive load curves to 50,000 feet at three different values of inductance-resistance are desirable. Since the objective in a switch test is to obtain a switch current rating under specified conditions of altitude and load, it follows that the major portion of the time allotted for the switch test should be spent in this effort.

In the resistive load test, while cycling the switch at 25 cycles per minute and observing the arc time on the oscilloscope, the current is increased until the critical arc time is approached. The critical arc time for the sea level condition can be estimated from the arc-time curves previously obtained. In a similar manner critical current values are obtained for altitudes up to 50,000 feet. It is suggested that 5,000-foot increments of altitude are adequate for rating the switch. Similar curves are then run with loads selected to cover the inductance-resistance range of 0.005 to 0.03.

Current-Carrying Capacity. Current-carrying capacity is determined by the I^2R loss in the contacts themselves. This power dissipation can be measured by running a curve of millivolt drop across the closed contacts as a function of current through the contacts. Ordinarily, the current-carrying capacity of the contacts will exceed the current-rupturing values. But should the contact heat generated at rated break current be excessive, the switch will have to be rated on the basis of current-carrying capacity. Acceptable contact temperatures or power dissipation values are dependent upon the materials and type of switch involved. In general, contact current-carrying capacity tests should not be made on new contacts but should be run after 50 per cent, and again, at completion of the life cycle test.

Switch Life Test. Once the rated current for the switch has been established from the altitude–versus–current-carrying-capacity curves, life tests can be run at boundaries of current, altitude, and inductance-resistance ratio established by this data. In setting up life tests the 14 factors or conditions outlined previously must be given consideration and adequately controlled or recorded. In life testing a switch the minimum life-cycle operations required by applicable specifications should be considered but not regarded as an objective or limit for any test aimed at really evaluating a switch. In general, the fewer samples available to establish satisfactory operation, the larger the number of life cycles should be. This is because with a large number of cycles, disturbing variables are more likely to be pinned down. But where critical use is to be predicated on very limited test work, then the boundaries of these limited test requirements must be set much higher to ensure an equal degree of security.

The number of switches required for a test evaluation will depend upon the completeness desired for the test. It is suggested that a practical number of test switches would be 20. Ten of these switches may be used to determine characteristics; the other ten should be life-tested at the conditions established or specified.

PERFORMANCE TESTING VERSUS ENGINEERING EVALUATION

THE previous discussion of switch testing was concerned with the determination of the rating for a switch. This problem is rightfully separate and different from the problem of testing for specification conformity. The proposed test is outlined with no intent to depart from the accepted military specification policy of stating all requirements in terms of required performance. However, following a specification policy does not mean that full-

scale engineering tests and consideration of switchgear is unnecessary or undesirable. The designer and applications engineer should know a lot more about a switch than a military specification would be justified in requiring.

THE INDUCTIVE LOAD FOR SWITCH TESTING

Of all the convenient approximations used by test engineers to describe operating conditions, probably none is more abused than the inductance-resistance ratio practice of describing inductive switch circuit loads. In fact, the simulation of aircraft circuit inductive loading for test purposes is far from acceptable. In the first place, very little data on the nature of aircraft inductive loads are available, and in the second place, it is doubtful whether existing terminology can be used without some invention to accurately express the nature of such iron-cored inductances where the iron is nearly always operated near saturation.

The inductance-resistance does not define an inductive switch load in a useful manner if it is determined from the current rise time or any other method that gives a determination of inductance on the basis of low-frequency changes in the circuit. The principal circuit interruption voltage peak occurs near the end of the interruption cycle and is a relatively high-frequency phenomenon of 10 to 200 microseconds duration. The voltage rise rates are of the order of 100 volts per microsecond. For these conditions low-frequency values of inductance have little significance. Dielectric losses and core losses are likely to be dominant factors in determining the peak voltage and energy values.

The optimum solution of the inductive load problem is to life-test the switch with the actual load that it is to operate on the airplane. When, as is usually the case, the actual load cannot be used in a switch test for reasons of excessive heating, mechanical limitation, or expense, an electric mock load is the next best solution. But this mock load, to be equivalent, should be adjusted to simulate actual aircraft equipment circuit interruption transients. Referring to Fig. 4, the load inductance may be an air-core coil of low distributed capacity and high-voltage layer insulation. The simulated load is adjusted with an oscilloscope to give a current rise time approximating the class of aircraft equipment for which the switch is being tested. But finally and most important, the resistance shunted across the inductance should be adjusted to give interruption transients similar to those observed or anticipated from properly insulated aircraft equipment under test. An oscilloscope capable of high-frequency response is required, and the input impedance of the oscilloscope connected across the test switch must be 1 megohm or higher.

RECOMMENDATION

Performance and reliability of aircraft switches must be improved if circuit interruption equipment is to keep pace with aircraft requirements. As a first step in achieving this goal, it is recommended that the scientific techniques, so effectively applied to the design and test of other seemingly more complex aircraft equipment, be also applied to the aircraft switch equipment. Scientific studies of this type will result in the establishment of basic design parameters that will eventually improve switch design and application.

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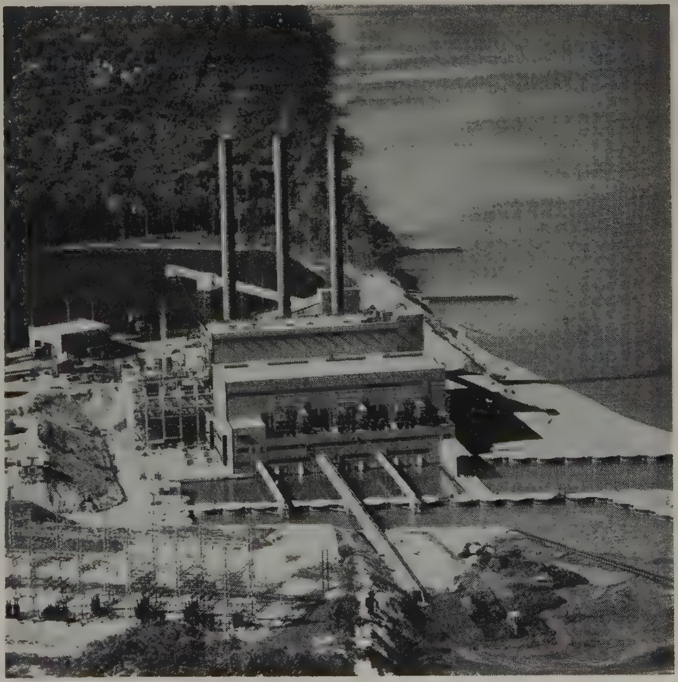
Illuminating Company Expands Power Capacity

The third 140,000-kw turbogenerator went into service at the Cleveland Electric Illuminating Company's Eastlake power plant recently, boosting capacity at the plant to 420,000 and illuminating system capacity to 1,564,000 kw.



As this third power producer came "on the line," construction crews at the Eastlake plant site were pressing forward with foundation footings for a giant 208,000-kw unit scheduled for completion late in 1955.

The 3 turbogenerators now in service are the largest and most efficient in the illuminating system to date, exceeding by 40 per cent the individual operating capacities of the 100,000-kw generators at the company's Avon power plant.

Upon completion of the fourth unit, one of the world's largest single-shaft generators, power capacity at Eastlake will reach 628,000 kw, with system capacity totaling 1,772,000 kw.

Since the end of World War II, the Illuminating Company has invested $222,000,000 in power generating, transmission, and distribution facilities. Programmed expenditures of $63,000,000 are being made to achieve a system capacity goal of 1,772,000 kw by year-end 1955.

Precision High-Current Computer Power Supplies

A. B. ROSENSTEIN
ASSOCIATE MEMBER

THE increasing size and complexity of analogue and digital computers has resulted in an ascending demand for expanding quantities of well-regulated and filtered d-c power. Regulated power demands have gone from milliamperes to hundreds of amperes.

This article describes high-current precision d-c power supplies that have been developed to meet the requirements of modern computers. The power supplies are unique in that for the first time a high-current magnetic-amplifier-controlled selenium rectifier has been produced with the response and electrical performance of the conventional electronic supply, and yet possessing the mechanical advantages and life of the magnetic amplifier.

The trend of computer design is toward compact high-performance machines capable of installation in an office or moderate-sized laboratory. The ideal power supply would be a sealed unit, completely static, with a service-free life of 10 to 20 years.

Full input to output efficiency of larger power supplies is receiving close scrutiny by computer designers. Designers are now calling for power supplies with over-all efficiencies of 70 to 75 per cent or better.

The electrical requirements of a computer power supply are dictated by the characteristics of the machine load. Although these requirements will vary from machine to machine, a reasonably uniform electrical specification usually can be drawn.

To design a computer's proper supply, its electrical output specifications must carefully spell out the required voltage response under all types of loading and with maximum variations in the a-c power input. Not only must the steady-state regulation be given, but ripple must be considered as an addition to the instantaneous dynamic regulation. Steady-state regulation, dynamic regulation, and ripple are each commonly specified to be held within anywhere from 0.1 to 1.0 per cent.

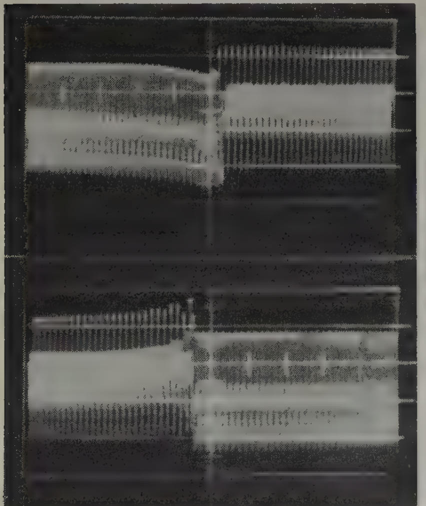
Table I. Physical and Electrical Characteristics of 225-Volt, 15-Ampere Precision Power Supplies

Characteristic	60-Cycle, Self-Cooled	400-Cycle, Forced-Cooled
Steady-state regulation	Better than ±0.1%	Better than ±0.1%
Dynamic regulation	Better than ±0.15%	Better than ±0.15%
Ripple	Less than 0.1% rms	Less than 0.1% rms
Efficiency	75%	71%
Volume	5.9 cu. ft.	1.5 cu. ft.
Weight	369 lb.	92 lb.

The magnetic-amplifier-regulated selenium rectifier achieves the full mechanical criteria for computer power supplies. The power section is completely static and composed of highly dependable elements of extremely long life. The components are capable of withstanding even a high shock test and prolonged vibration. The over-all bulk is at practically the irreducible minimum, consistent with today's materials. Temperature characteristics are excellent.

Table I gives the physical and electrical characteristics of a small computer power supply rated at 225 volts and 15 amperes. The steady-state regulation of the supply is ±0.1 per cent, while the dynamic load regulation with ±20 per cent load changes does not exceed ±0.15 per cent. It is to be noted from the oscillographs, Figs. 1 and 2, that the dynamic regulation due to a step change in load or a-c supply is practically the same as the steady-state regulation. As the response of the power section is only 1/6 cycle, this small difference between dynamic and steady-state regulation for nominal load changes is found to be in the damping circuits of the preamplifier, not in the power section.

Experience has proved the ability of the magnetic amplifier to perform the high-speed high-current regulating tasks formerly considered feasible only with thyratrons or ignitrons. With reasonable response and ripple specifications, there are no practical limits to the size of the magnetic amplifier computer power supply.



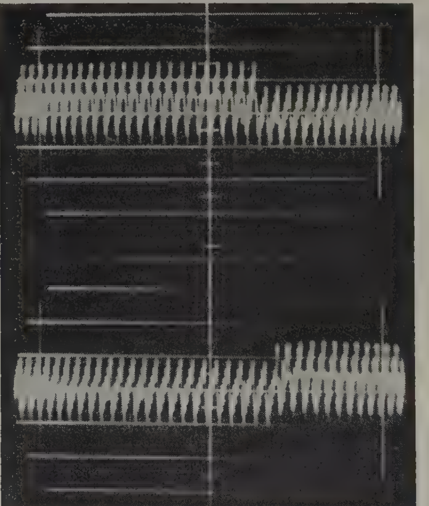


Fig. 1 (left). Dynamic load regulation, 40 per cent step change in load. (top). 120 per cent, 80 per cent. (bottom). 80 per cent, 120 per cent. (Each major division = 0.25 volt). Fig. 2 (right). Dynamic line regulation at 100 per cent load. (top). 240 volts, 220 volts. (bottom). 220 volts, 240 volts. (Each major division = 0.25 volt)

Digest of paper 54-313, "Precision High-Current Computer Power Supplies," recommended by the AIEE Committee on Computing Devices and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, Los Angeles, Calif., June 21–25, 1954. Published in AIEE *Communication and Electronics*, September 1954, pages 405–09.

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Detection of Corona in Oil at Very High Voltages

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CORONA is a manifestation of ionization in an insulating medium. Under many conditions corona is detrimental to insulation and consequently should be avoided in electric equipments. Among the various means of detecting corona, such as visual, audible, electrical, etc., the electrical means of detection has been considered most sensitive and has been in use for a number of years.

More recently, the cathode-ray-oscilloscope technique with electronic amplifiers has been applied to corona detection, giving additional information on the distribution of corona occurrence in time and phase relations with the applied voltage. One disadvantage of this method, however, has been the difficulty of distinguishing the corona signals produced by the test sample from those caused by external disturbances, especially extraneous corona in the high-voltage test circuit.

It is feasible to completely eliminate corona in the test circuit for relatively low-voltage test samples such as cables, capacitors, and insulating materials of small dimensions. Excellent results have been obtained with the use of filters, large diameter leads, and smooth connections at test voltages up to 100 kv.

For higher voltages, however, it is generally found not to be practical and often impossible to eliminate circuit corona with these means. Therefore, some means must be used to facilitate the distinction between the circuit corona and the sample corona. Since the test samples of the higher-voltage classes are invariably oil immersed, the problem becomes a matter of differentiating corona in oil from that in air surrounding the high-voltage circuit.

Corona in oil is characterized by its relatively high intensity even at start, and by its random occurrence at any phase of the applied voltage. Circuit corona, on the other hand, is characterized by its definite phase relationship with the voltage wave, and its intensity is much higher in the positive half-cycle than in the negative half-cycle. It is this positive corona or streamer that is hard to differentiate from oil corona and should be eliminated. This paper demonstrates that by the use of small diameter wires for the high-voltage line and a multiple point structure (called a "Crown of Thorns" on the bushing dome), the high-intensity streamer can be completely eliminated up to half a million volts or at even a higher testing voltage if desired. The remaining circuit corona is of such a low magnitude and definite phase distribution that it can be easily distinguished from corona in oil on a cathode-ray oscilloscope with a conventional neutral current detection circuit as shown in Fig. 1.

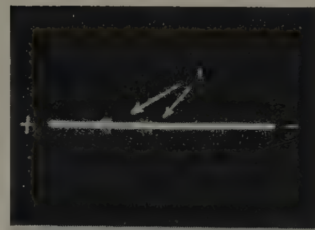

Fig. 2. Typical corona oscillograms taken during tests on terminal board samples

(Above left). 200-kv applied voltage, (1) Slight circuit corona, no oil corona in sample; (above right). 220-kv applied voltage, (1) Slight circuit corona, (2) Oil corona in sample; (right). 200-kv applied voltage, test piece capacitance increased to 300 micromicrofarads by paralleling with entrance bushing, (1) Circuit corona, high-frequency haze background, (2) Oil corona in sample

In order to monitor a wide range of corona intensities simultaneously on an oscilloscope, a dual-frequency dual-sensitivity detecting element has been devised. Several typical oscillograms taken during tests on a terminal board sample are shown in Fig. 2.

Although there are some limitations to this type of corona detection, it has been proved to be a very useful tool in the development of almost all kinds of insulating structures in large power transformers, such as windings, thyrite stacks, cable assemblies, tap changers, bushings, and basic insulating materials.

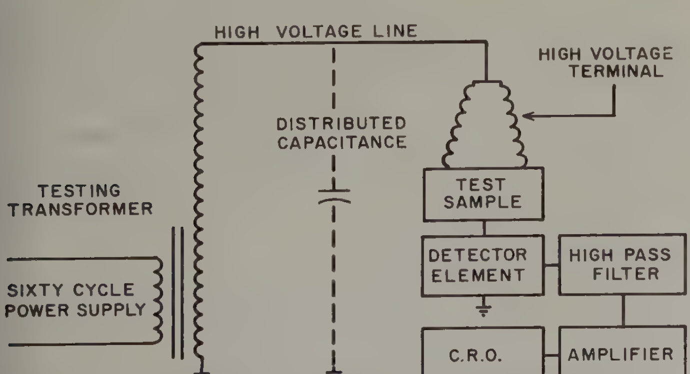

Fig. 1. Basic corona detection circuit using cathode-ray-oscilloscope technique

Digest of paper **54-396**, "Detection of Corona in Oil at Very High Voltages," recommended by the AIEE Committee on Transformers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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Demonstration of the Principles of the Ultrasonic Flowmeter

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By transmitting ultrasonic frequency both upstream and downstream between two fixed transducers, large volumes of a liquid can be measured with great sensitivity. The electronic apparatus used is not complicated and velocity of the liquid can be determined with a precision of one per cent.

THE ULTRASONIC flowmeter, utilizing sound having frequencies above the audible range, has been made practical for the measurement of liquid flows as large as 10,000 cubic feet of water per second in hydroelectric turbines. To give an impression of the magnitude of such a quantity of water, Fig. 1 shows one of the three openings carrying water to a large hydraulic turbine.

The new flowmeter is the result of a search for a simpler, less expensive, yet accurate method of measuring large volumes of flowing water. A new technique is employed, wherein sound is transmitted both upstream and downstream between two fixed elements. The measurement is one of great sensitivity, measuring changes in sound velocity of only one part in half a million for precisions of the order of one per cent in the determination of water velocity.

Since the ultrasonic flowmeter is based upon the propagation of compressional waves in the moving fluid, a demonstration of some of the analogous properties of water surface waves is helpful for an understanding of the principles of the method.

A white enameled pan, about 12 inches by 20 inches, is filled to a depth of about one inch with water tinted with vegetable dye. By means of side lighting and a mirror tilted at an angle of 45° over the pan, an audience can see surface-wave behavior in the pan.

By dipping a pencil in the water, a simple circular wave pattern is produced such as that shown in Fig. 2*a*. By repeatedly dipping the pencil and changing its position along a straight line by about 1 inch between successive dips, the effect of relative fluid movement can be shown as in Fig. 2*b*.

Fig. 1. An intake to a large hydraulic turbine with a 30-foot transducer (thin light line on wall) installed

It can be seen that the wavelength increases when the waves propagate counter to the motion of the pencil and decrease for propagation in the opposite direction. These changes in wavelength are measures of the velocity of the moving source. Identical changes in wavelength would occur for a stationary source and the medium moving with the same velocity.

For certain applications, such as the measurement of discharge through hydraulic turbines having intakes with rectangular cross sections, it is essential to produce a linear wavefront rather than the common circular one. Such a wave can be simulated in the pan of water by drawing the pencil in a straight line through the water. The wave behavior is illustrated in Fig. 3 where the source moves in a straight line with velocity V_s and the wavefront propagates with the velocity V_p. The angle of radiation $\theta=\cos^{-1} V_p/V_s$ is shown and is an important factor when mounting linear transducers. Such transducers produce straight wavefronts by propagating compressional waves in a slender rod from which waves are radiated into the fluid in the manner depicted in Fig. 3. Provision is made at the end of the rod for absorbing any excess energy which has not been radiated.

In an actual flowmeter, the waves in the fluid to be measured are generated by a transducer energized with alternating current. A convenient way of measuring the changes in wavelength is to measure changes in the phase angle between the voltages at the transmitting and receiving transducers when transmitting both upsteam and downstream. This is demonstrated with the air flowmeter shown in Fig. 4 where 4-inch permanent-magnet speakers are the transducers converting electric energy into acoustic energy and vice versa. Fig. 5 is the block diagram of the equipment.

One oscilloscope is used to show by a Lissajous figure the phase angle between the sinusoidal voltages at the speakers. The second oscilloscope and the electronic

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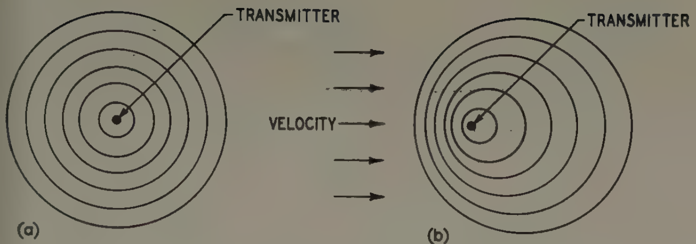


Fig. 2. Circular wave patterns of a stationary point source, where in a, the medium is stationary and in b, the medium is moving with a uniform velocity

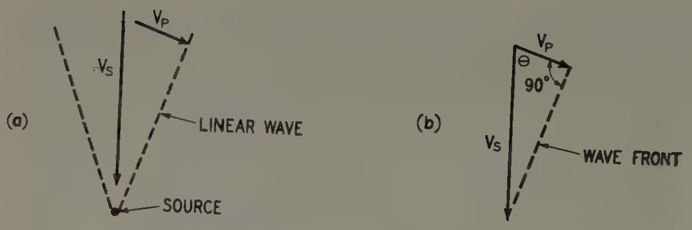
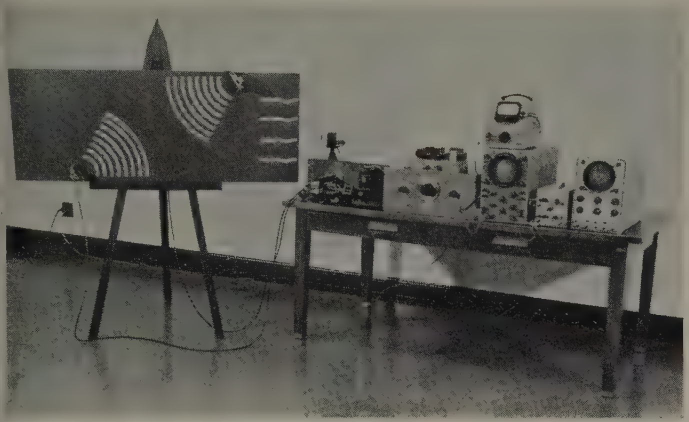


Fig. 3. Linear wavefront of a moving point source, where V_S is the velocity of the source and V_P is the velocity of propagation in the liquid



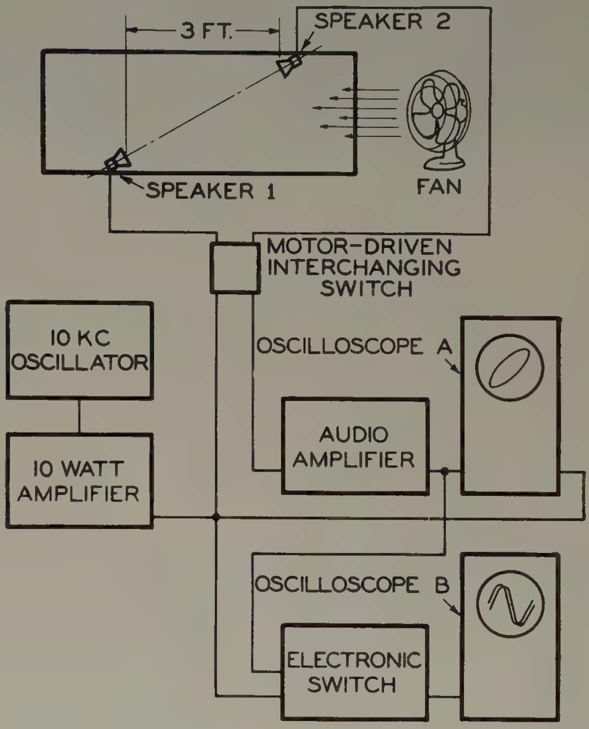


Fig. 4 (above). In this demonstration apparatus, the electric fan produces air flow, simulates liquid flow between the two loudspeakers on the board. Under the fan is the motor-driven interchanging switch next to the 10-kc oscillator, then the two oscilloscopes with the electronic switch between them. Fig. 5 (right). Block diagram of the flowmeter demonstration apparatus of Fig. 4. The phase angle is displayed as a Lissajous figure on oscilloscope A and as sine-wave displacement on oscilloscope B

switch show this same phase angle, but by the relative positions of superposed images of the two sine waves.

With no air flow, the phase relationship between the speaker voltages for the static condition can be seen on the oscilloscopes. Since the frequency used for the demonstration is about 10 kc, there are about 30 waves in the train between the speakers which are 40 inches apart. The presence of these waves can be shown by interposing a barrier between the speakers and by the change in phase angle on the oscilloscopes as one speaker is moved slowly toward the other.

When motion of the air between the fixed speakers is produced by an electric fan, the change in phase angle from the static condition is apparent on the oscilloscopes. The interchanging switch shown in Fig. 5 cyclically reverses the direction of transmission between the transducers. This bidirectional technique is used to eliminate errors caused by minute transducer motions and temperature changes.

Placing a barrier to one side of the direct path between speakers introduces reflections, or multipath transmissions. These cause more than one signal to be received and can introduce errors into the flow measurement. This behavior illustrates the difficulties sometimes encountered when applying the method without adequate knowledge of radiation characteristics.

Flow velocity is calculated from the following formula:

$$v=\frac{V^2}{fd}\times\frac{\Delta^\circ}{720^\circ}$$

v = flow velocity, feet per second
V = absolute propagation velocity, feet per second
f = frequency of ultrasonic waves, cycles per second
d = projection of transducer spacing on axis of flow, feet
Δ° = difference between the phase angles measured when transmitting with and against flow, degrees

Since the ultrasonic method is an absolute one, requiring no calibration by other means prior to its use, this formula contains no empirical coefficients, only fundamental units of time and length.

In order to keep Δ within a practical range of one wavelength (360°) or less for the flow velocities to be measured, the frequency can be chosen to satisfy conditions imposed by the absolute propagation velocity of the fluid

to be measured, and the length d of the measuring section available. Some typical relationships of these factors as follows:

Application	V, Feet per Second	d, Feet	f, Kilocycles
Demonstration air flowmeter	1,100	3	10
Hydraulic laboratory model	4 800	1	500
Hydroelectric turbine intake	4,800	10	25

One of the interesting possibilities of the ultrasonic flowmeter is the measurement of the flow of fluids whose properties are known only approximately. If the absolute transit times with and against flow were measured, instead of the difference in transit times as utilized in the previous formula, only the fixed physical dimensions of the measuring section are significant as indicated by the following formula.

$$v=\frac{d}{2\sin^2\phi}\left[\frac{1}{t_d}-\frac{1}{t_u}\right]$$

$$\phi=\tan^{-1}\frac{d}{w}$$

w = width of measuring section

t_d = transit time for a compression wave to travel downstream from one transducer to the other

t_u = transit time for a compression wave to travel upstream from one transducer to the other

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A New Electrical Hygrometer

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FELLOW AIEE

The basic element of this hygrometer is an alumina core saturated with a chemical solution which will absorb atmospheric moisture and so become electrically conductive. Functioning on 120-volt a-c supply, it will give enough current to operate an a-c relay between relative humidities of 20 to 100 per cent.

MUCH WORK has been done on electrical hygrometers for response to changes in atmospheric humidity. This is well summarized and many references are listed in a Bureau of Standards' publication.[1] Satisfactory devices for some applications are available.

The type of device described here was developed for use with a 120-volt a-c supply to provide sufficient current to operate directly a low-cost, available a-c relay. It is for relative humidities between 20 and 100 per cent and provides a simple method of adjustment for operation through a wide range.

THE SENSITIVE ELEMENT

THE BASIC element of this device is a small cylindrical ceramic core of pure low-fired alumina which has been saturated with a water solution of a chemical salt that will absorb moisture from the atmosphere and thus become conducting. The outside of this small ceramic cylinder is made with a double helix spiral thread. This provides for two windings of small platinum wire that form the two electrodes making contact with the ceramic. An important feature is the use of one of these platinum wire windings to pass a heating current that raises the temperature of the core. This allows adjustment of the device to operate a relay at a desired value of relative humidity. This feature also has other uses which will be described subsequently.

The choice of a chemical with which to saturate the core is an important factor as it determines the conductivity of the ceramic material, which for practical considerations must be kept within certain limits. Lithium chloride, a favorite one for hygrometers, is suitable for use for low humidities at low ambient temperatures, whereas sodium dichromate is more suitable for the higher range of humidities at high temperatures. Thus, the treatment of the core may be determined by the range of relative humidity through which the element is to function. Special requirements may dictate the use of other chemical compounds.

The core is mounted in a small 3-pin radio tube base. The third base pin is to provide a second connection to one winding which is also the heater coil. To shield against air currents and for mechanical protection, the element is fitted with a perforated plastic or metal cover. The unit is shown in Fig. 1.

ELECTRICAL CHARACTERISTICS

FUNDAMENTALLY in this device, the element varies in resistance with variations in humidity. Actually

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the fact that the conduction current of a few milliamperes through the ceramic is sufficient to heat the core slightly above ambient and that this heating can be further increased a controllable amount by current through the heating coil provides additional interesting and useful characteristics.

When the element is connected directly across a 120-volt a-c line with only an a-c milliammeter in series, the relation between percentage relative humidity and conduction current through the ceramic will be nearly a straight line over a wide range of relative humidity values above some minimum value. This is shown in Fig. 2. This and succeeding characteristic curves are for a typical element. The use of different chemical salts does not change the general nature of these relationships, but can change the current values through a wide range.

If now the core temperature is raised further by a small current through the heater coil to add, say, 0.1 watt, then the conduction current will drop to follow a lower and nearly parallel curve due to the further drying out of the core.

However, at a constant given value of humidity, the volt–ampere characteristic will be as shown in Fig. 3. This indicates that at constant humidity but over a wide range of voltage, such as 30 to 300, the resistance of the core adjusts itself either by an absorption or drying-out action so that it operates at a nearly constant wattage. The higher the relative humidity, the higher this value of constant wattage.

The initial response to a change in voltage resembles that of an ordinary resistor. In a few moments, however, the current change reverses. Therefore, after the initial effect has passed, an increase of applied voltage will result in an almost proportional decrease in resulting conduction current.

If, however, the circuit includes a high impedance (of the order of 50,000 ohms or more), the characteristic is quite different, as shown in Fig. 4. This difference is due to the fact that, as increasing humidity lowers the resistance of the core, the voltage across it drops and therefore there is a further drop in resistance. Thus, the characteristic curve is steepened which is useful for a more accurate closing of a relay at a more definite value of humidity. With certain combinations of the parameters, this rise may be the equivalent of a sudden change between two stable conditions.

Again as in the case of the simpler circuit, the addition of heater coil current shifts the curve to a lower but fairly parallel value. This, of course, provides a method of operating the relay at some particular value of humidity.

There is a limit to the impedance that can be usefully employed in series with this element at a fixed line voltage. As series resistance is added, the voltage drops across the element and, as has been explained, the conductivity of the element increases. This continues until the resistance of the element becomes so low that the added series resistance becomes the determining factor for current in the circuit. This is shown in Fig. 5. When this point is reached, the self heating of the element is negligible and it continues to absorb moisture from the atmosphere.

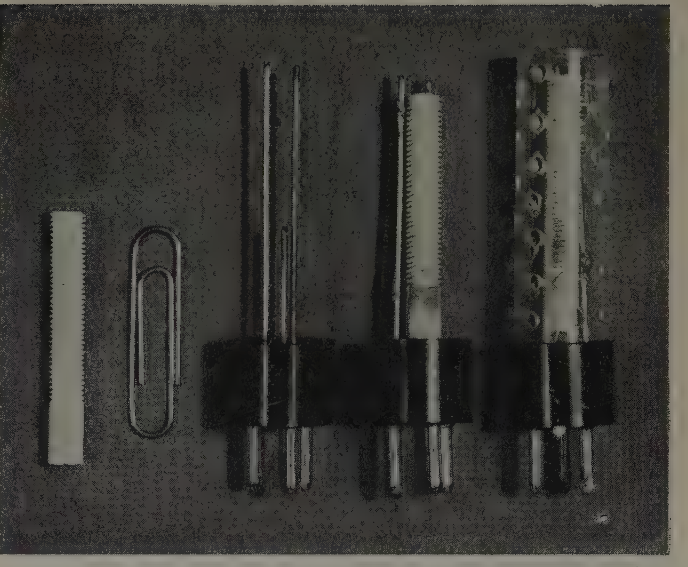


Fig. 1. Parts and assembly of the hygrometer element shown with an ordinary paper clip for size comparison

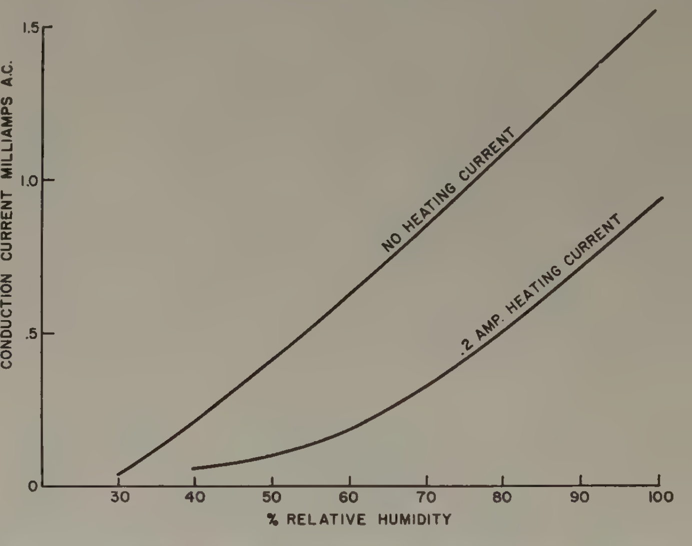


Fig. 2. Relation between conduction current and relative humidity with 120 volts a-c across element. Shows effect of heater current

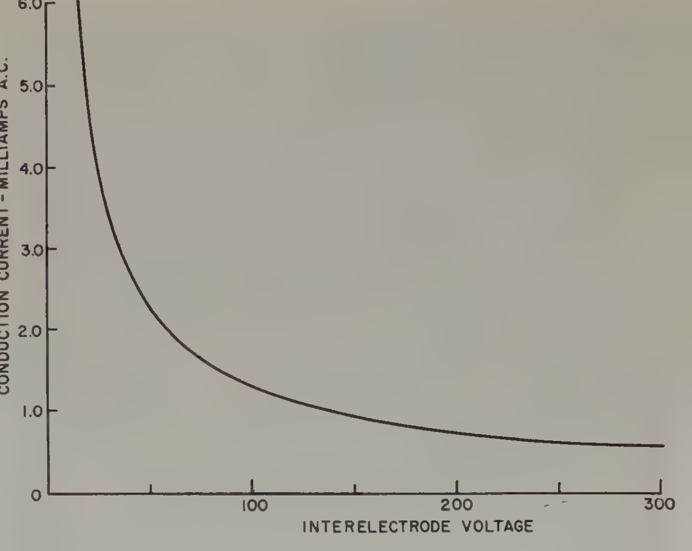


Fig. 3. Volt–ampere characteristic of an element at a constant relative humidity and no heater current

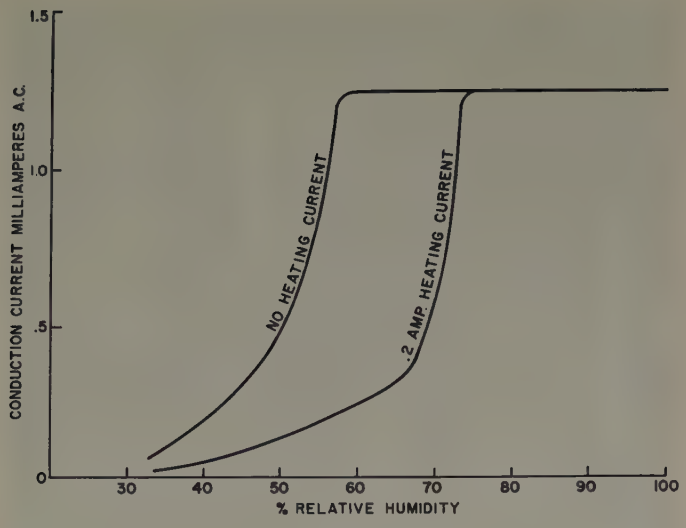


Fig. 4. Relation between conduction current and relative humidity with a high impedance, such as a relay coil, in series with element

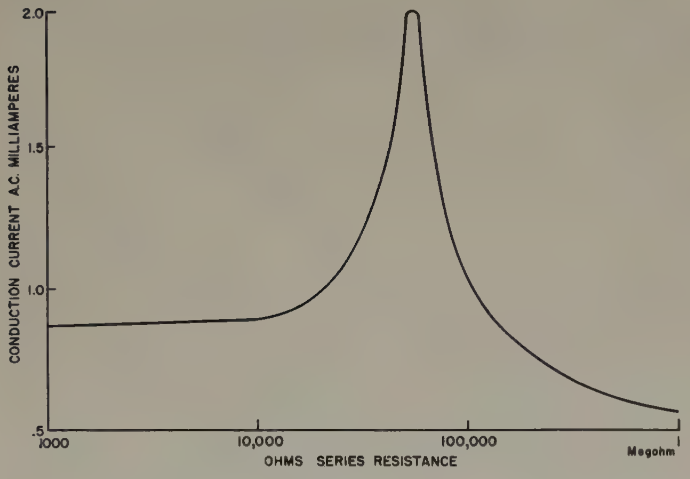


Fig. 5. Relation between conduction current and resistance in series with the element. Constant humidity and line voltage

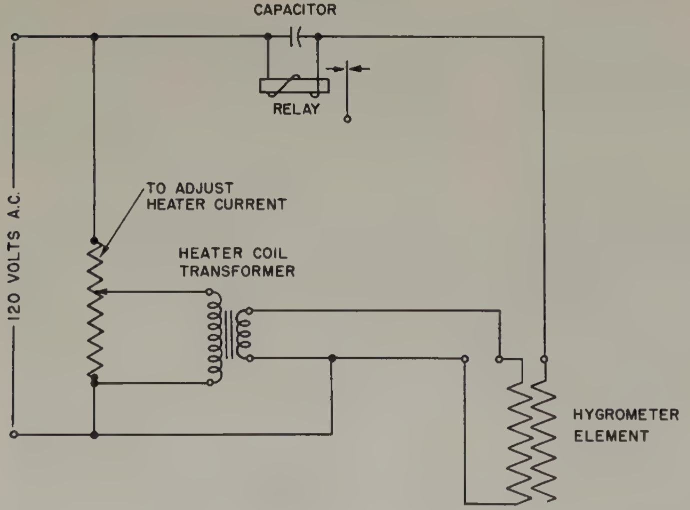


Fig. 6. A simple form of relay circuit for use with the sensitive element

The same thing will occur if the element is allowed to stand disconnected from a voltage supply in a humid atmosphere. It can be easily and quickly restored to normal operating condition by the brief application of heater current.

With the several parameters involved in this device, it is possible to have a wide variety of characteristic curves. All curves shown are for room temperature conditions.

OTHER CHARACTERISTICS OF THE ELEMENT

Temperature Coefficient. These elements, being electrolytic conductors, have a definite negative temperature coefficient of resistance. As the ambient temperature rises, the conductivity of the element increases. This change can be compensated by a slight increase in heater current. This may seem contradictory but it is to be remembered that an increase in element temperature above ambient introduces a drying-out action which is much more pronounced in changing the element conductivity than a change in ambient temperature. Conversely, if the element is exposed to moving air, this will cool the ceramic which increases its absorption of water vapor from the surrounding air and this increases its conductivity. Therefore, it is apparent that at constant humidity the controlling factor is the temperature of the element relative to ambient.

Speed of Response. This will vary widely with ambient temperature and relative humidity. For high humidities at high temperatures, it is a matter of only a few minutes. At temperatures around 0 C and low relative humidities, say, under 30 per cent, it is much slower, an hour or even much more. As has already been mentioned, a slight change in heater current can compensate for these changes in ambient temperature.

Effect of Water Condensation. If the core of the element becomes actually wet with water, it must be dried out with a heater current for an hour or more, but a marked permanent change of characteristic is improbable for one such immersion. Exposure for more than a few moments to a flow of steam may alter the characteristic of the element, however.

Currents corresponding to over 100-per-cent humidity will be indicated temporarily if there is a condensation of water on the element, such as occurs when it is exposed to the breath.

Effect of Sudden Increases of Humidity. If an element is changed quickly from a very low humidity to a very high one, the absorption of water vapor is so rapid that the conduction current will rise initially far above that corresponding to 100-per-cent humidity before giving a correct indication. This is due to the fact that the moisture absorption of the ceramic core takes place more rapidly than its temperature rise from the I^2R heating effect of the conduction current.

Variations in Characteristics. Within limits, variations in electrical characteristics as between elements, changes in ambient temperature, line voltage, and heater current produce characteristic curves that are very nearly parallel.

This facilitates the use of slight changes in heater current to compensate for most of the variables encountered.

APPLICATION

For Instrumentation. For use with indicating or recording instruments, it is highly desirable to include some sort of protective resistance in series with the element. This is necessary because, as has been stated, when the elements stand disconnected, they continue to absorb moisture until their resistance is so low that when reconnected to the line enough current may pass to damage the instrument. On the other hand, too high a value of added resistance will impair the linear relation between per-cent relative humidity and conduction current through the element.

The solution of this problem is to use one or more small diameter filament lamps in series with the element. Two small candelabra-base 10-watt 230-volt lamps in series are satisfactory. Their cold resistance is low enough to preserve linearity of response and their hot resistance high enough to afford protection to the instrument against current overload. Also they will pass some current to supply a little heat to dry out a saturated element over a period of time.

As has been noted, most of the variations encountered result in parallel characteristic curves; therefore, the zero adjustment of the instrument can be used for changes in calibration. This, of course, is on the assumption that a rectifier-type instrument with a uniform scale is used. Such an instrument is also desirable from the standpoint of usefulness over a wide range of currents.

For most uses with an instrument, heating current in the element is not necessary. Therefore, only the two current limiting lamps are required in addition to the element and instrument.

It must be remembered that humidity conditions in rooms are subject to wide and sudden fluctuations and may vary with location of the instrument. It is sometimes difficult, therefore, to get comparative readings from different humidity measuring devices, particularly if their speed of response differs.

For Relay Operations. As has been pointed out (compare Figs. 2 and 4), the inclusion of a high impedance, such as a relay, in series with the element produces a marked change in the relation between element conduction current and relative humidity. This steepening of the characteristic curve is helpful, of course, in operating the relay at a certain desired value of humidity.

It is helpful also to shunt the relay coil with a capacitor to effect a certain amount of tuning. This permits the relay coil current to be higher than the current through the element; in other words, it provides a better impedance match between the relay coil and element. Choice of the value of this capacitor also permits, in such an arrangement, some degree of control between pickup and drop-out current in the element circuit. A simple relay circuit is shown in Fig. 6.

If desired, the circuit may include provision (not shown in Fig. 6) for stepping up the heater current when the relay closes to minimize overshooting of the change of humidity. This can be done to such an extent that the whole circuit continually cycles between "off" and "on." Thus, it can be adjusted so that at about 100-per-cent humidity it is "on" all of the time while at some lower value it is "off" all of the time. At values of humidity between these two, it will cycle, the ratio of "on" to "off" periods of time being proportional to the humidity.

REFERENCE

1. Methods of Measuring Humidity and Testing Hygrometers. U. S. National Bureau of Standards, Washington, D. C., Circular 512, 1951.

New Steam Generating Unit Goes Into Operation at Ford Motor Company

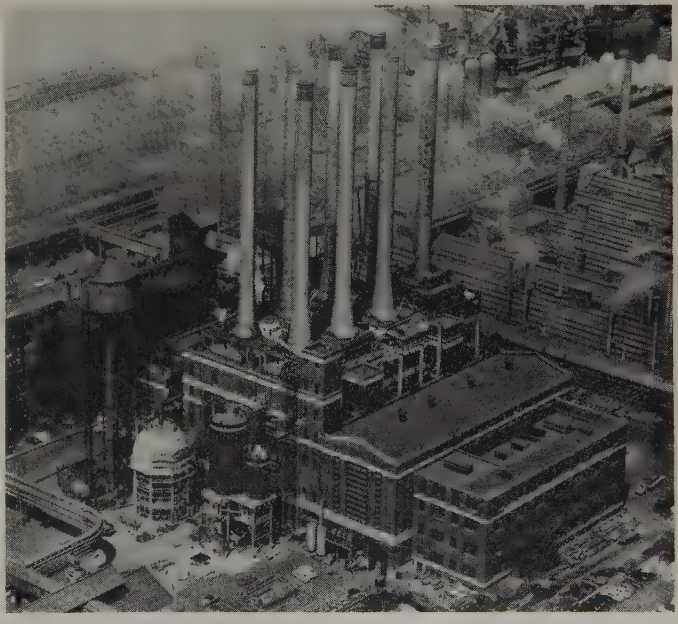
The first of three new boilers—one of the largest low-pressure steam units in industry—has begun its job of supplying power for Ford Motor Company's Rouge Plant in Dearborn, Mich.

This is the latest in a series of modernization steps, all within the original floor space, that will eventually see the plant's original steam generating equipment quadrupled in capacity, with all but one of the original boilers replaced.

The new 7-story-high boiler can produce up to 60,000 pounds of steam per hour at 250 pounds per square inch gauge, 650 F. This is nearly double the hourly steam output of the old boiler.

Besides replacement of three of the plant's eight units, the modernization programs calls for installation of dust collectors, fly-ash and bottom-ash handling equipment for all eight units, and a 200,000-gallon-per-hour hot lime process water softener system.

A view of Ford's world-famous Rouge Power Plant is shown on the right.



Alteration of Dynamic Response of Magnetic Amplifiers

R. O. DECKER
ASSOCIATE MEMBER

A MAGNETIC AMPLIFIER of the full-wave self-saturating type has a delay similar to that of an inductive circuit if the residual delay of the amplifier is neglected. The sinusoidal transfer function of the magnetic amplifier without feedback is

$$\frac{E_0}{E_c}(jw)=\frac{K\dfrac{N_c}{R_c}}{1+jwT_A}, \tag{1}$$

where K is a gain constant in volts per ampere turn, N_c is the number of control turns, R_c is the control circuit resistance, and T_A is the time constant of the amplifier, which is proportional to N_c^2/R_c. The block diagram of the amplifier is shown in Fig. 1*A*.

Feedback through frequency-sensitive networks placed in series with isolated windings can be used to alter the dynamic response of the magnetic amplifier. An analysis of the amplifier when feedback is applied through nonloading feedback windings results in the following sinusoidal transfer function

$$\frac{E_0}{E_c}(jw)=\frac{N_c}{R_c}\,\frac{1}{1+jwT_A}\,\frac{K}{1+K\dfrac{(1)}{(1+jwT_A)}\dfrac{(N_f)}{(Z)}} \tag{2}$$

This transfer function is exactly that obtained by considering the block diagram shown in Fig. 1*B*. From this diagram it can be seen that if the feedback circuit does not load the control circuit, the feedback windings will present a negligible inductance to the feedback signal, but the feedback signal to the summing point is delayed by the time lag of the control winding.

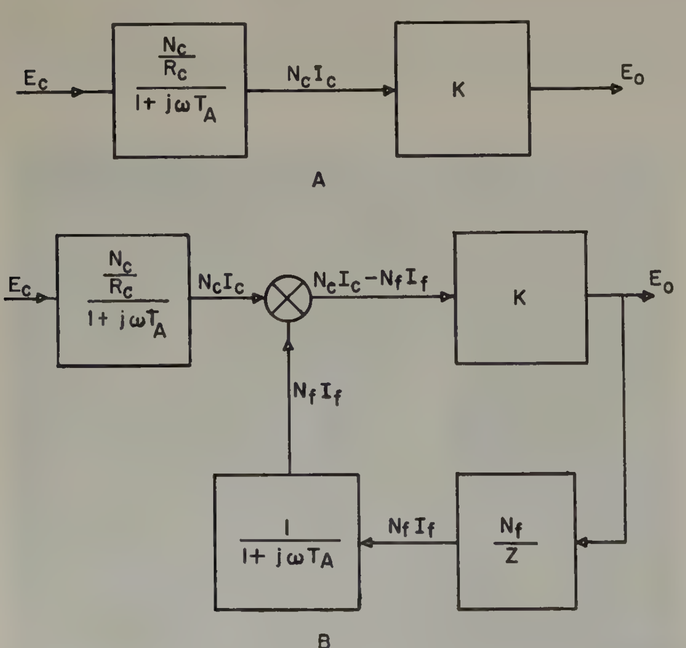


Fig. 1. Block diagram of magnetic amplifier: A—Without feedback; and B—With feedback into separate windings

The transfer function given in equation 2 can be extended to yield a generalized equation for the sinusoidal transfer function of a single-stage full-wave magnetic amplifier with feedback through a network that has no more than one energy storage element. This generalized transfer function is

$$\frac{E_0}{E_c}(jw)=\frac{K^1(1+jwT_1)}{1+jwT_2-w^2T_1T_3} \tag{3}$$

T_1, T_2, and T_3 are time constants associated with the feedback networks and the amplifier. The amplifier can be made to exhibit phase lead or lag characteristics by adjusting the parameters of the feedback networks; thus, it can be used effectively to reshape the open-loop frequency locus of a servo system.

The validity of the generalized transfer function has been checked by experimental testing on 60- and 400-cycle push-pull magnetic amplifiers with reversible polarity d-c outputs. To facilitate comparison of experimental and theoretical data, the generalized transfer function was put in the following normalized form

$$\frac{E_0}{E_c}(jw)=\frac{K^1\left(1+j\left(\dfrac{w}{w_n}\right)\alpha\right)}{1+j\left(\dfrac{w}{w_n}\right)\beta-\left(\dfrac{w}{w_n}\right)^2} \tag{4}$$

where

$$w_n=\frac{1}{\sqrt{T_1T_3}};\quad \alpha=\sqrt{\frac{T_1}{T_3}};\quad \beta=\frac{T_2}{\sqrt{T_1T_3}}$$

For a wide range of values of α and β, the amplitude and phase angle of the normalized equation versus the normalized frequency ratio (w/w_n) were computed by the use of a digital computer, and curves were plotted of the amplitude and phase angle of the normalized equation. For a number of curves, the frequency-sensitive portion of the normalized equation was checked by experimental testing on the 60- and 400-cycle push-pull amplifiers.

Good correlation has been obtained between the theoretical expressions and experimental data. Small differences which exist are due to second order effects which have been neglected in the analysis, such as the residual delay of the amplifier and the loading effect of the feedback windings.

The generalized equation has been used successfully in predicting the response characteristics of feedback amplifiers that have been used in many practical servo systems.

Digest of paper 54-376, "Alteration of the Dynamic Response of Magnetic Amplifiers by Feedback Techniques," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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An Improved Wide-Range Adjustable-Speed Drive

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An adjustable-speed drive using a d-c series generator supplying a d-c series motor is described. It operates well at speeds under 10 rpm as well as at speeds limited only by mechanical considerations. The ratio of maximum to minimum speed is in the order of 100 to 1.

IT has been pointed out in a discussion of an adjustable-speed drive that a d-c series motor will operate at an essentially constant speed when it is supplied with a voltage proportional to its input current.[1] This principle of operation has been employed in a simplified supply system in which the number of machines has been reduced and in which the control equipment is made more practical. An extension of the theory of this type of drive to include saturation effects of both motor and generator is approached by graphical analysis.

The circuit, which consists of a d-c series generator (with a control field) supplying a d-c series motor is shown in Fig. 1. The generator is driven at constant speed. The control field is used to aid or oppose the series field of the generator. Changing and field rheostat setting changes the terminal voltage characteristic of the generator, and for each setting of the rheostat the motor maintains essentially constant speed with varying load. By means of the field-reversing switch, the generator terminal voltage characteristic can be made either higher or lower than the characteristic obtained with the series field only. With the control field opposing the series field, the control circuit resistance may be decreased to the value of the winding resistance only. However, with these fields aiding, the control circuit resistance must be kept high enough so that the generator cannot build up an appreciable voltage without the aid of the series field. The generator thus never operates as a constant-voltage compound machine.

ANALYSIS

AN approximate graphical analysis provides a direct approach for obtaining the characteristics of this drive. It is assumed that the generator-control field current is negligibly small compared to the motor current. This condition can be obtained by making the number of control-field turns sufficiently greater than the number of series-field turns. Thus the generator and motor armature currents are essentially the same.

Several curves of terminal voltage V_t versus current I for the generator are shown in Fig. 2. The symbols are defined in Fig. 1 and Table I. The curve *1*, for $G_f = 0$, is the terminal characteristic with no control field excitation. If a series motor having the same voltage–current characteristic for a particular speed is electrically connected to this generator, the drive would exhibit constant speed under all conditions of loading. For the case when I_f and I produce aiding magnetomotive forces ($G_f > 0$) and when the resistance and armature reaction voltage drops are neglected, the field current I_f is proportional to the line voltage V_t. For any particular value of V_t there is required less line current I by an amount FI_f, which equals FG_fV_t. For a given F and G_f the dashed line in Fig. 2 can be constructed. The current FG_fV_t gives the magnetomotive force effect of the control field in terms of an equivalent-

Table I. Definitions of Symbols

	Machine 1, Generator	Machine 2 Motor
Terminal voltage	V_t	V_t
Motor armature current		I
Generator control field current	I_f	
Reciprocal of control field resistance (mhos)	G_f	
Ratio of control field turns to series field turns	F	
Speed	N_1	N_2
Generated voltage	E_{g1}	E_{g2}
Armature resistance	R_{a1}	R_{a2}
Series field resistance	R_{S1}	R_{S2}
Induced emf per rpm per ampere in series field	K_1	K_2

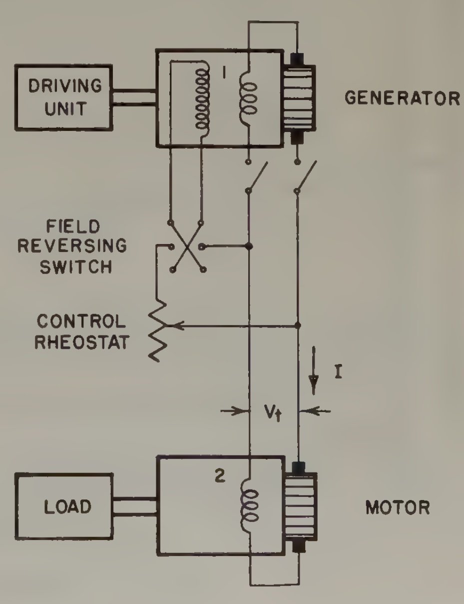

Fig. 1. Circuit diagram

Full text of paper 54-322, "An Improved Wide-Range Adjustable-Speed Drive," recommended by the AIEE Committee on Rotating Machinery and approved by AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

A. G. Conrad, A. R. Perrins, and **R. R. Shank** are with the Dunham Laboratory, Yale University, New Haven, Conn.

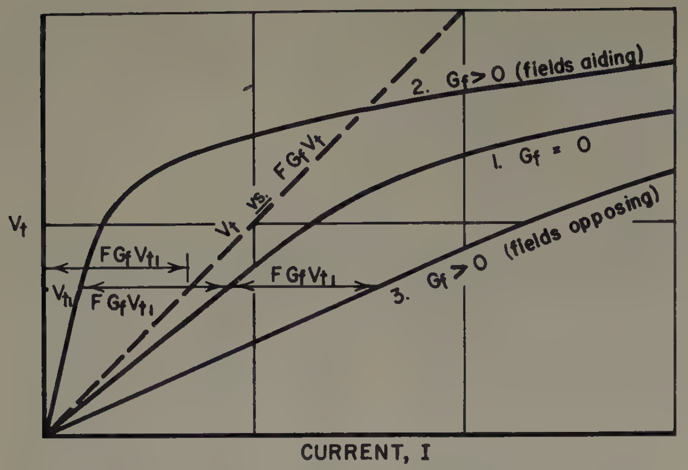

Fig. 2. **Idealized terminal characteristics of generator**

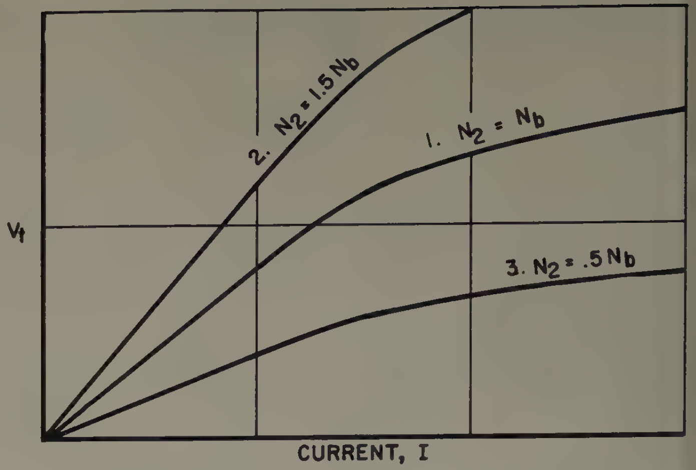

Fig. 3. **Idealized terminal characteristics of motor**

series field current. Curve *2* is to the left of curve *1* by FG_fV_t, and can therefore be readily constructed. For every value of I there is a higher value of V_t for curve *2* than for curve *1*. For the motor characteristic to approximate curve *2*, its speed must take on a higher value than for curve *1*.

If the control field of the generator is reversed, curve *3* is obtained for the particular G_f chosen above. This results in a slower motor speed. The generator curve *3* for opposing fields is more nearly linear over the range of load currents than curve *1*, since it contains the linear component FG_fV_t and because of the lower saturation.

A terminal voltage–current characteristic (curve *1*) for the motor running at base speed N_b is shown in Fig. 3. For half of the base speed the characteristic has been approximated by taking one-half the voltage for each value of current I. For 150 per cent of the base speed, the two curves are added. A value of input current to the motor determines the terminal voltage of the generator, Fig. 2, and the motor runs at the speed which gives the same terminal voltage for the particular current value, Fig. 3. Since the generator curve for $G_f = 0$ and the motor curve for N_b give the same terminal voltage–current characteristic, the motor maintains speed N_b for all values of current I. From the fact that different techniques were used to obtain the curves other than the base curves, it follows that generator and motor characteristics cannot be completely matched at all speeds. For example, if the control field rheostat is set for operation on generator curve *2* (Fig. 2), visual comparison of this curve and motor curve *2* (Fig. 3) shows that for increasing values of current I, the motor must run at decreasing values of speed. For good performance in the high-speed range, a motor must be chosen which operates higher on its saturation curve than the generator does on its curve (at the base-speed setting). The combination of machines having the characteristics of Figs. 2 and 3 gives the best speed regulation at speeds equal to and lower than the base speed. Thus for any desired range of speeds with good regulation, a suitable combination of generator and motor can be chosen. The wider the range of speeds chosen, the more necessary it is to confine operation to the linear portions of the saturation curves of the generator and the motor.

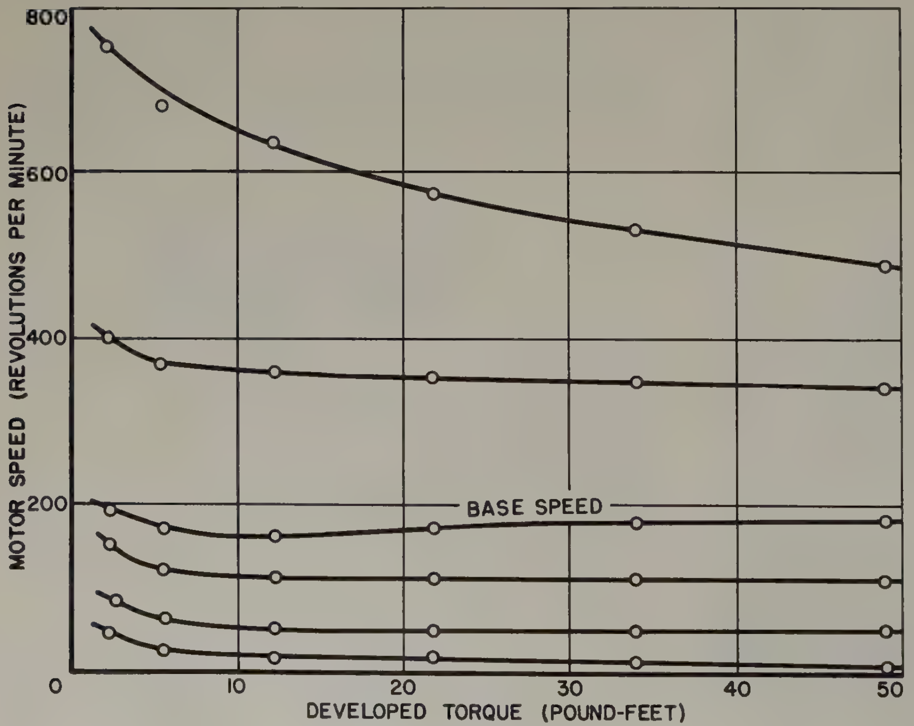

Fig. 4. **Speed-torque characteristics**

PERFORMANCE

THE experimental steady-state speed-torque characteristics of this drive are shown in Fig. 4. The data for these curves were obtained from standard machines available in Dunham Laboratory of Electrical

Engineering at Yale University. The generator speed was maintained constant. No special attempt was made to choose machines having matched characteristics, but it appears that they were effectively matched at the base speed. As predicted above, the high-speed characteristics show decreasing speed with increasing torque.

The approximate graphical analysis overlooks special effects occurring under conditions of low values of output torque. The residual magnetism is important, since it enables the generator voltage to build up. At low currents the residual magnetism causes the generator to produce essentially constant voltage, and the series motor shows its characteristic increase in speed with decrease in load as this condition would demand.

The transient performance at very low speeds, under 10 rpm, is quite remarkable. Application of increased load slows the motor momentarily, after which the voltage and current build up until the speed returns to its original value and the machine supplies the larger torque. However, a discussion of this transient behavior and the margin of stability is beyond the scope of this article.

GENERAL CONSIDERATIONS

The drive discussed in this article is an improvement over that proposed by A. G. Conrad and E. R. Tribken, even though the installed capacity must be the same in each case. The improved drive requires a generator and its driving unit, each having the full rating of the motor driving the load. Only one generator is used, whereas in the earlier drive two generators were required. Adjustment is obtained in the low-current control field circuit, rather than by use of a diverter rheostat on the series field winding of the generator. Thus the control circuit design places no limitations on the power handling capacity of the drive. The behavior at slow speeds is excellent, and a very wide range of speeds is attainable.

The design of the drive to meet certain specifications does involve a careful choice of machines, but the circuit is simple. No exciters are used, nor are electronic control circuits employed. It is possible to operate the motor at a location remote from the generator and its driving motor, since the control field voltage is taken from the generator terminals. Only two lines to the motor are necessary.

Appendix

An approximate steady-state algebraic analysis may be obtained by assuming linear magnetization curves for both machines. Further, armature reaction will be assumed to be minimized by compensating windings and therefore it will not be considered here. The control field current I_f is negligibly small in comparison with terminal current I, and thus the generator and motor currents are assumed to be equal. The voltage equation for the system is

$$E_{g1}-(R_{a1}+R_{s1})I=E_{g2}+(R_{a2}+R_{s2})I \tag{1}$$

The voltage induced in the generator is proportional to the speed and to the flux, which has been assumed to be a linear function of magnetomotive force

$$E_{g1}=K_1N_1(I\pm FI_f) \tag{2}$$

The voltage induced in the motor is proportional to the speed and to the flux, which is assumed proportional to the current

$$E_{g2}=K_2N_2I \tag{3}$$

The field current I_f is given by

$$I_f=G_fV_t=G_f[E_{g2}+(R_{a2}+R_{s2})I]=G_fE_{g2}+G_f(R_{a2}+R_{s2})I \tag{4}$$

Substituting 4 into 2

$$E_{g1}=K_1N_1I\pm K_1N_1FG_fE_{g2}\pm K_1N_1FG_f(R_{a2}+R_{s2})I \tag{5}$$

Substituting 5 and 3 into 1

$$K_1N_1I\pm K_1N_1FG_fK_2N_2I\pm K_1N_1FG_f(R_{a2}+R_{s2})I-(R_{a1}+R_{s1})I= K_2N_2I+(R_{a2}+R_{s2})I \tag{6}$$

The current I is common to all terms, and N_2 may be found to be

$$N_2=\frac{K_1N_1\pm K_1N_1FG_f(R_{a2}+R_{s2})-(R_{a1}+R_{s1})-(R_{a2}+R_{s2})}{K_2+K_1N_1FG_fK_2} \tag{7}$$

If the speed N_1 of the generator is constant, then for each setting of the control rheostat all terms in the right hand member of equation 7 are constant and N_2 is constant. A change in the setting of the control rheostat changes the value of G_f, and this results in a different value of N_2. Thus the speed is constant for each rheostat setting, but it is adjustable over a very wide range.

Reference

1. A Wide-Range Adjustable-Speed Drive, **A. G. Conrad, E. R. Tribken.** AIEE *Transactions*, vol. 68, pt. 1, 1949, pp. 789–90.

New Method of Machining Hard Materials Is Demonstrated

Ultrasonic impact grinding is a new means of machining hard and brittle materials such as glass, hardened steel, semiprecious stones, ceramics, and tungsten carbide by ultrasonics. Developed by Raytheon Manufacturing Company of Waltham, Mass., the ultrasonic machine tool cuts intricate shapes in materials that formerly were difficult or impossible to machine.

The new tool was put through its paces before a group meeting recently. In describing the principles behind the ultrasonic machine tool at that time, spokesmen for the Waltham electronics firm explained that it makes use of the peculiar phenomenon called "magnetostriction." The word describes an action peculiar to certain metals, notably nickel, which contract and expand minutely when subjected to an alternating magnetic field. The Raytheon machine tool employs this principle to vibrate a cutting tool at an ultrasonic rate.

The tool is lowered until it is lightly in contact with the surface of the work, which is placed on the work-table. An abrasive suspended in a liquid is flowed over the work in a continuous stream. The power is turned on and the tool, moving up and down at ultrasonic speed, drives the tiny abrasive particles into impact with the work. Owing to the tremendous deceleration, the particles strike the work with forces up to 10,000 times their normal weight. This action cuts away the material.

Saturating Transformer Reference Circuit

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In regulating and control systems the quantity to be controlled is compared to a reference quantity. The difference or error is used to maintain the controlled quantity near a fixed value. Currents or voltages are often used in electric systems as reference quantities. These currents or voltages are supplied from circuits which must be unaffected by input variations or ambient temperature variations, because the controlled quantity will vary as the reference quantity varies.

The average rectified output voltage of a transformer made with rectangular hysteresis-loop core material will remain constant as the input voltage varies if the input voltage always causes the core to saturate. Since little flux change can occur after the core saturates, the volt-second area transformed into the transformer secondary is constant if the input volt-second area saturates the core. The volt-seconds which can be applied to a core before saturation occurs are not a function of frequency. Consequently, the volt-seconds on the secondary are constant as the frequency of the input voltage varies. However, the average value of the rectified output of such a transformer varies linearly as the input frequency varies, because the number of volt-second areas per given unit of time varies as the frequency varies. Transformers operated into saturation are termed saturating transformers. A resistance is connected in series with the input of a saturating transformer to limit current flow after saturation. A saturating transformer can be used to provide an electrical reference quantity if the input frequency is constant.

Fig. 1 shows a circuit which employs a saturating transformer and a frequency-compensation circuit. R is the current-limiting resistor; T, the saturating transformer; L_1 and L_2, linear inductors; and RECT, a dry disk rectifier such as a selenium rectifier. If the input is sinusoidal, the waveforms are as shown. The change in current i_1 is essentially the area of the voltage pulses e_s divided by the inductance L_1. The peak-to-peak value of i_1 is constant if the input voltage and frequency vary. The rectified value of i_1 is shown as the dotted lines on the graph of i_2. As i_1 decreases from the value of $X/2$ when e_s decreases, the polarity of L_2 reverses in attempting to maintain i_2 constant. When the peak value of i_1 is less than the peak value of i_2, the rectifier becomes biased,[1] and i_1 and i_2 may flow through the rectifier without interaction. From time 3 to 4 the current i_2 will remain nearly constant if the time constant of $(L_1+L_2)/R'$ is long as compared to the period of the input. R' is the sum of the rectifier (forward resistance), load, and copper resistances. At time 4, i_1 is less than i_2 and the rectifier becomes biased. Then i_2 is determined by the time constant of L_2/R'', where R'' is the resistance of the rectifier (forward), the load R_L, and the copper of L_2. At time 5, i_1 and i_2 are equal again, and the rectifier ceases to be biased. Then i_2 is a function of L_1+L_2 as e_s changes. The circuit of Fig. 1 will thus provide relatively constant output current i_2 as the magnitude and frequency of the input voltage varies.

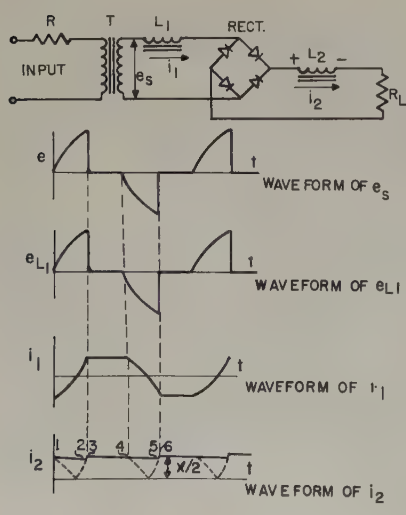

Fig. 1. Saturating transformer reference circuit

Variation of the characteristics of the components of Fig. 1 as the ambient temperature varies has negligible effect upon the reference output except in the case of T. The output of the reference is a function of the saturation flux of T. The saturation flux of T has been found to decrease about 0.07 per cent per degree centigrade increase in temperature in the case of 50-50 nickel-iron magnetic alloys. The current i_2 will vary in the same manner. R_L may be divided into two parallel resistors. If one of the resistors varies with temperature, the current in the other resistor may be held constant.

A practical example made from commercially available components has the following characteristics:

Input	Output
100 to 140 volts	Temperature compensated for −55C to +100C ambient
360 to 440 cps	15 ± 0.2 milliamperes
5 watts	50-ohm load

The device has a volume of 15 cubic inches and weighs 1.5 pounds. A large number of similar reference devices are in service in military and commercial applications.

Since all of the reference components are static and inherently reliable, the reference device is ideally suited for critical military and commercial applications. The components are such that negligible variations in the output should occur over periods of service in the order of years.

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The Maximum Response Ratio of Linear Systems

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WHAT is the maximum amplitude that can be obtained in a linear time-invariant transmission or control system subjected to inputs with limited amplitude? This question is important in many physical problems. Suppose b is the bound on the magnitude of the input amplitude and h_0 is the smallest number such that the response $h(t)$ satisfies $|h(t)| \leq h_0$. Then the maximum response ratio r is defined by $r = h_0/b$. With this terminology, the question becomes: What is the value of r?

Let $w(t)$ denote the response of the system under consideration to a unit step function input applied at time $t = 0$. In general, the step response $w(t)$ will have alternate maxima and minima occurring at times $t = t_1, t_2, t_3$, etc. For example, consider the typical step response shown in Fig. 1. In this case there are relative maxima at $t = t_1$ and $t = t_3$. Discernible minima occur at $t = t_2$ and $t = t_4$. Since the last of the maxima and minima is one of the latter, the function rises to its final value, denoted by $w(\infty)$. The maximum response ratio r for a system having this step function response is given by the expression

$$r = 2[w(t_1) + w(t_3)] - 2[w(t_2) + w(t_4)] + w(\infty) \tag{1}$$

Thus the maximum response ratio r is equal to twice the sum of the relative maxima minus twice the sum of the relative minima plus or minus (plus in this case) the final value. The plus sign is used before $w(\infty)$ if $w(t)$ increases to its final value and the minus sign is used if $w(t)$ decreases to its final value.

This word statement is the general rule. Although it is stated in terms of a finite number of maxima and minima, this is no real restriction. Even in the case of a theoretically infinite number of oscillations, the contribution after a few terms is usually negligible. Certainly to experimental accuracy, only those terms which are detectable can influence the results significantly. If the last of these is a relative minimum, then the function is assumed to rise to its final value. If it is a relative maximum, then the function is assumed to decrease to its final value.

The exact computation of the step response and hence the maximum response ratio r is tedious, even for a simple system, if oscillations are present in the step response. To alleviate this situation, an inequality has been developed which gives a bound on r. In general, this is not a least upper bound, so that the result is pessimistic. However, numerical examples have shown the bound to be reasonable for certain typical systems encountered in controls work.

Linear time-invariant systems are characterized by a transfer function, which is denoted by $G(s)$, where s is the complex variable $s = \sigma + j\omega$. Under the usual conditions of stability, $G(s)$ is analytic for all $\sigma > \sigma_0$, where σ_0 is negative. In this case the following inequality holds

$$r^2 \leq \frac{1}{2a}\frac{1}{2\pi j}\int_{c-j\infty}^{c+j\infty} G_{-a}(s)G_{-a}(-s)\,ds, \quad a<|\sigma_0|/2, \quad -a\leq c\leq a \tag{2}$$

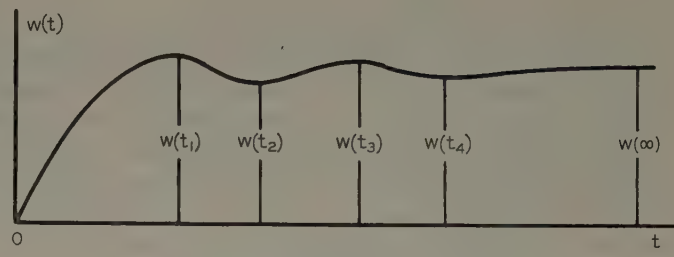

Fig. 1. Response to a unit step function

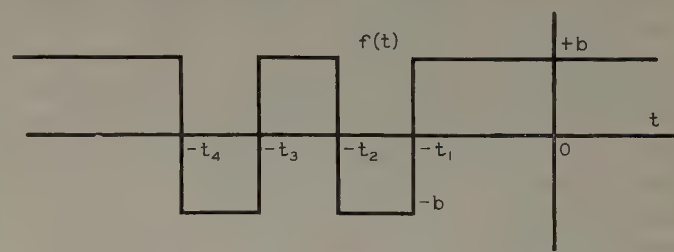

Fig. 2. Function producing maximum output at time t=0

where the function $G_{-a}(s)$ is defined to be $G(-a+s)$. In most cases of interest, $G(s)$ and hence $G_{-a}(s)$ is a rational function of s having real coefficients. As a consequence, the integral may be evaluated by well-known techniques developed for such integrals arising in problems of filter or control system optimization.

The problem which led to this investigation involved a servomechanism which uses a digitalized or quantized pickoff on the output. The quantized signal may be considered the true signal plus a "disturbance." The latter is bounded by plus or minus one quantum or digit. Viewed in this manner, the disturbance signal is effectively fed into the input of the servo. Under the assumption of linearity of the equivalent system, the effect of the disturbance can be no greater than the maximum response ratio r times the physical amount represented by one quantum of signal. If this effect is sufficiently small, then the effect on the positional accuracy should be negligible.

It would seem that a knowledge of the maximum response ratio r could be useful in many other situations. For instance, in quasi-linear systems the linear ranges of various elements in the system put limitations on the allowable input level for linear operation. Determination of the allowable limit on the input might well be accomplished by using linear analogues and establishing the permissible ranges experimentally, using the step response as outlined in this digest.

Digest of paper 54-371, "The Maximum Response Ratio of Linear Systems," recommended by the AIEE Committee on Feedback Control Systems and approved by the Committee on Technical Operations for presentation at the Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Applications and Industry*, 1954.

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An Alpha Plotter for Point-Contact Transistors

T. P. SYLVAN

A test set for showing a plot of alpha versus emitter current on an oscilloscope is described. It is useful in the application of point-contact transistors in large-signal switching circuits.

THE alpha–emitter current characteristic is of great importance in large-signal applications of point-contact transistors. The majority of these applications consist of switching and computing circuits that utilize the inherent ability of the point-contact transistor to present a negative resistance characteristic at its input terminals by virtue of the fact that alpha exceeds unity in the active region.[1] A common property of these circuits is their possession of two definite states; they are either "off" or "on." The speed at which they switch from "off" to "on," and the degree to which they are "off" or "on" is determined by the negative resistance characteristic which, in turn, is governed by alpha. Consequently, an alpha plot can serve as a figure of merit for point-contact transistors in switching as well as other similar applications.

An ideal alpha–emitter current curve is illustrated in Fig. 1*A*. Note the rapid increase in alpha as the emitter current increases positively through zero. The slope of this segment of the alpha curve is a measure of the ability of the transistor to switch rapidly from an "off" to an "on" state. A large slope is desirable.

Alpha usually decreases from its peak value as I_e continues to increase positively. If alpha decreases too rapidly as in Fig. 1*D*, the negative resistance of the transistor is insufficient and it operates poorly as a regenerative switch. On the other hand, if alpha shows additional peaks or exceedingly high values with increasing I_e as in Fig. 1*C*, the transistor may show tendencies to be unstable and to oscillate.

Furthermore, the alpha plot is a function of the collector voltage. Fig. 1*B* indicates a transistor that performs poorly at low collector voltages.

Earlier alpha plotters were instruments of the tall relay-rack type. The circuits utilized vacuum tubes requiring large power supplies. Also, some equipment contained built-in oscilloscopes, vacuum tube voltmeters, etc. At the General Electric Company, the Advanced Electronics Center's philosophy is aimed towards utilizing generally available laboratory instruments in conjunction with a compact low-cost alpha plotter. This type of test set is believed to be especially attractive to commercial or military engineering laboratories engaged in transistor application work.

The alpha plotter whose design and operation are the subject of this report is patterned functionally on the Bell Telephone Laboratories design; but all the circuitry is original. In fact, the circuitry was transistorized and plotted wherever possible, so that this design is superior to the previous ones in numerous respects. For instance, this superiority is obvious as far as space, weight, and power consumption are concerned.

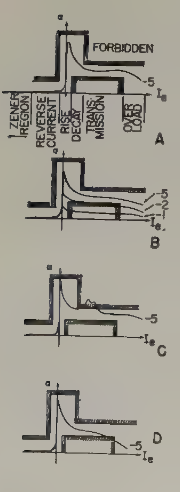
OBJECTIVES

This project was undertaken with the following purposes:

1. Survey the work done by other laboratories in the design of alpha plotters.
2. Establish the degree of usefulness of this type of instrument as evidenced by the results of survey of the other laboratories' work.
3. Design, construct, and test a portable, easy-to-use test set for displaying α versus I_e on an associated oscilloscope.

BLOCK DIAGRAM

THE alpha-versus-emitter current plotter is shown in block diagram form in Fig. 2. Fig. 3 is a schematic of the alpha-plotter. This test set provides voltages proportional to alpha and I_e for oscilloscope display.



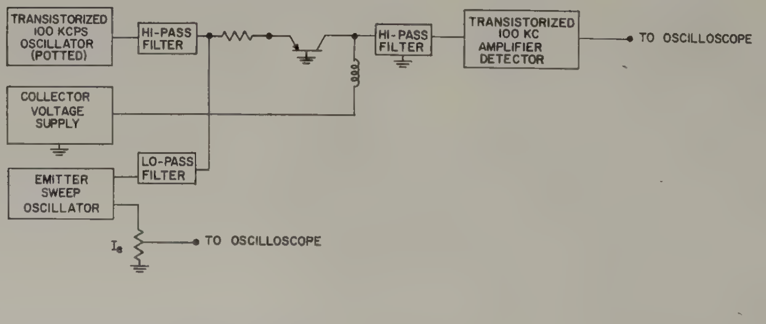


Fig. 1 (left). Typical alpha versus emitter current curves of point contact transistors: *A—Ideal; B—Family with the collector voltage as parameter; C—Typical example of erratic behavior; D—Example of early overload.*
Fig. 2 (above). Block diagram alpha versus emitter current sweeper

The second of a series of three special articles on point-contact transistors to be published in *Electrical Engineering*. "Testing Point-Contact Transistors for Pulse Applications" by T. L. Wooley appeared in the October 1954 issue, pp. 981–7.

T. P. Sylvan was formerly with the General Electric Company, Advanced Electronics Center at Cornell University, Ithaca, N. Y., and is now working on an advanced degree at Cornell University.

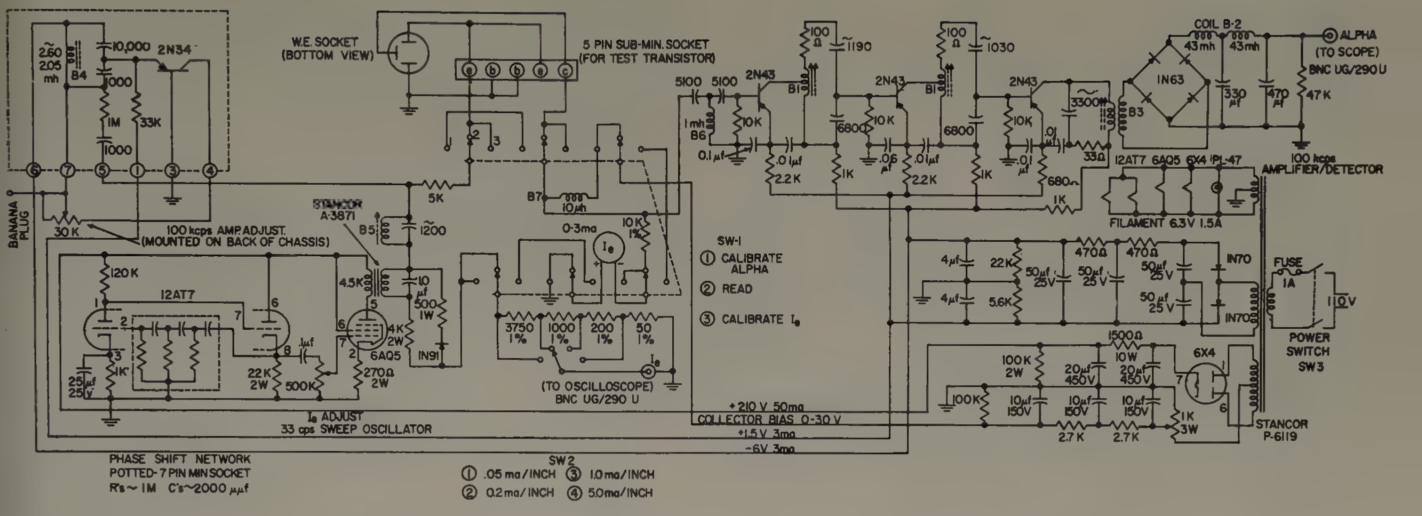


Fig. 3. **Point-contact transistor alpha plotter, schematic diagram**

In contrast to the laborious and time-consuming point-by-point methods, this plotter provides a fast and more complete way of observing the variation of alpha with emitter current and collector voltage.

The emitter sweep oscillator provides the emitter "bias" current for the transistor. It oscillates sinusoidally at 33 cps; its output is directly coupled to the horizontal input of the oscilloscope.

The 100-kcps oscillator provides the small "signal" current by means of which alpha is measured. The composite emitter current is composed of this signal current superimposed upon the "bias" current. A high-pass filter isolates the 100-kcps oscillator from the sweep oscillator; and, conversely, a low-pass filter isolates the 33-cps oscillator from the signal oscillator. In order to guarantee that the transistor input always presents a positive resistance so that undesirable oscillations are avoided, an external resistor is inserted in the emitter lead.

The composite collector current is composed of a 100-kcps signal superimposed upon the 33-cps bias. Alpha, the a-c short-circuit current gain, is the ratio of the magnitude of the 100-kcps current component at the collector to the magnitude of the 100-kcps current component at the emitter. This ratio (alpha) varies with the amplitude of the sweeping emitter bias in the manner indicated by Fig. 1.

Since the 100-kcps signal component at the collector is rather small, amplification is necessary before detection and transmission to the vertical input of the oscilloscope. A high-pass filter is inserted to isolate the amplifier-detector from the 33-cps bias current.

Examples of waveforms are shown in Fig. 1. The abrupt changes in alpha, and the irregularities displayed by faulty units, show the definite need for a simple visual means of observing this characteristic. The fast rise times also indicate the need for a wide-band amplifier.

Calibration of the instrument is achieved by means of internal circuitry. Alpha calibration is made against a unity reference obtained on the oscilloscope by short-circuiting the emitter to the collector leads and opening the base circuit. I_e calibration is achieved by applying a measured current to the emitter circuit. Fig. 4 shows the details of the alpha plotter.

33-CPS SWEEP OSCILLATOR

The 33-cps oscillator provides the current that biases the emitter. Both the sweep trace and retrace can be utilized without blanking, with the result that any hysteresis effects produced by the transistor become apparent. In practice, it is found that on the higher sweep ranges or with the higher oscilloscope amplification, slight phase shifts in the 100-kcps amplifier and the oscilloscope amplifiers become apparent so that the trace and retrace patterns are slightly displaced with respect to each other. In this case, it is necessary either to recognize the correct trace, or to blank one of them. The swept emitter current swings both positive and negative; thus, the transistor characteristics on either side of the origin are displayed. Care must be taken to avoid exceeding the maximum *reverse* voltage ratings of the test transistor. The circuit shown in Fig. 5 illustrates one of the methods of limiting the magnitude of the reverse voltage applied to the emitter of the transistor.

The frequency of 33 cps was selected for the following reasons:

1. 33 cps is above the flicker frequency, yet still low enough so that both display bandwidth and signal frequency are minimized.
2. 33 cps is neither a multiple nor a submultiple of 60 cps, so that any pickup originating in the power circuits is immediately apparent and may consequently be eliminated.

The circuit consists of a conventional phase-shift oscillator employing a 3-mesh feedback network.[3] This type of oscillator was selected because it requires a minimum of components and insures a relatively pure sinusoidal output waveform. Also, the frequency is relatively independent of the supply voltage. The *12AT7* twin triode provides within a single envelope both an amplifier and a buffer stage. The *6AQ5* produces the power required to drive the emitter of the transistor under test. The load in the

emitter circuit is approximately 7,000 ohms. This sweep oscillator is capable of delivering 80 volts rms across this load which corresponds to a peak emitter current of 11 milliamperes.

TRANSISTORIZED 100-KCPS OSCILLATOR

A DISPLAY band of 6 kcps was chosen for the alpha-versus-I_e waveform for reasons which will be discussed later. Filtering design considerations dictated a signal frequency at least one decade above the top display harmonic of 6 kcps, so 100 kcps was chosen. The oscillator circuit provides an emitter signal current of 1 microampere. This circuit[4] was chosen because of its extreme simplicity and good characteristics. It requires no specially constructed components, and it gives stability of output waveform and tolerance to component and voltage changes comparable to that of conventional tube circuits. Power supply drain is less than 50 microamperes. The inductance of 2.2 millihenries is a simple untapped winding with a Q of 50. The optimum tank capacitor ratio was found to be about 10. The 33-K resistor mainly determines the angle of conductance of this Colpitts class *C* oscillator and hence the current drain. Distortion results if a resistance less than 25 K is used, and the output voltage is reduced sharply if larger values are used. The 30-K potentiometer in the collector circuit limits the forward collector-current flow when the collector is positive and provides a control of the oscillator amplitude. Together with the resistive component of the inductance, it prevents clipping of the output voltage waveform. This circuit is potted to maintain a high degree of stability in the circuit.

HIGH-PASS FILTER

SINCE the 33-cps emitter-current component is about 40 db greater than the 100-kcps component, it is necessary to attenuate the 33-cps signal before passing the collector signal to the amplifier-detector circuit. A simple T-type section is used for this purpose as shown in Fig. 5. The 33-cps attenuation is approximately 80 db while the attenuation of the 100-kcps signal is about 3 db.

The input impedance of the combined filter and amplifier-detector circuit is less than 1,000 ohms so that the approximation to the short-circuit collector requirement for the measurement of alpha is adequate. A low-impedance path of about 600 ohms is provided for the 33, cps signal through the collector voltage supply.

TRANSISTORIZED 100-KCPS AMPLIFIER-DETECTOR

THE 100-kcps amplifier is used to amplify the 100-kcps collector signal. This amplifier is a 3-stage stagger-tuned circuit using three transistors in the grounded-emitter connection. Impedance matching between stages was accomplished by the use of inductance-capacitance circuits tuned to approximately 100, 108, and 92 kcps. The Q of the resonant circuits was about 33 and the over-all bandwidth (half-voltage points) was approximately 12 kcps. The frequency characteristics of the amplifier-detector system are shown in Fig. 6.

The choice of emitter and collector bias resistors was not critical except in the last stage where a careful selection had to be made to preserve the over-all linearity of the amplifier. A certain amount of negative feedback has been incorporated by the choice of decoupling capacitors used.

The envelope detector uses a simple full-wave bridge with *1N63* whisker diodes followed by a 2-section *L*-type low-pass filter. Careful selection of the values of the components in the filter circuit had to be made so as to provide maximum filtering without sacrifice of circuit response or linearity. The variation in the forward resistance of the diodes with voltage made it necessary to use a high value for the series resistance in order to preserve the over-all linearity. To prevent excessive broadening of the trace on the oscilloscope, it was necessary to provide sufficient attenuation of the a-c component of the rectified signal which required high values of capacitance and inductance. On the other hand, the necessity of reproducing the alpha curve accurately required a low time constant for the filter circuit, which in turn required low values for the capacitance and inductance. A compromise gave a value for the broadening of the trace of less than 0.5 per cent and a time constant for the filter circuit of about 40 microseconds. This filter circuit gave satisfactory correspondence (a minimum of hysteresis) between the waveshapes for the trace and retrace except for the highest sweep ranges with the greatest magnification.

The 100-kcps input current is the quantity which is proportional to alpha. It is to be displayed on an oscilloscope with a relatively high input impedance. A linear relationship is thus required between the input current and the output voltage of the system. A plot of the output voltage versus the input current indicates good linearity for input currents up to 5 microamperes. Since the 100-kcps emitter current is adjusted to approximately 1 microampere this indicates linear reproduction of alpha up to a value of 5.

As stated previously, the bandwidth of this amplifier is approximately 12 kcps. This provides a 6-kcps display band either side of the 100-kcps signal center frequency. The number of harmonics

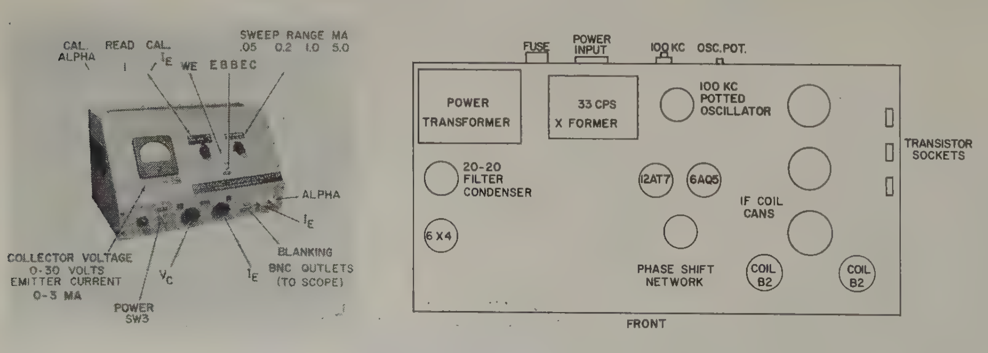


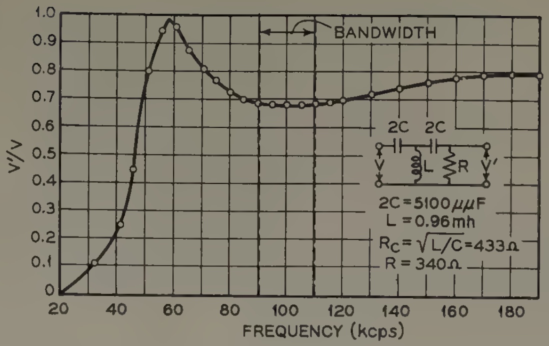
Fig. 4. Detail of point-contact transistor alpha plotter: *Left—Front view; Right—Top view of chassis arrangement*

passed by this amplifier is then slightly more than 150. Experience indicates that this is adequate.

POWER SUPPLIES

A FULL-WAVE rectifier and a voltage-doubler circuit provide all voltages necessary to operate the alpha plotter. The full-wave rectifier contains a voltage divider to provide outputs of +210 volts, 50 ma, and 0 to −30 volts. The former supplies plate voltage to the 33-cps sweep oscillator while the latter supplies collector voltage to the test transistor.

The voltage-doubler circuit utilizes the 5-volt filament winding of the power transformer. Its output is also applied to a voltage divider to provide outputs of −6 volts, 3 ma, and +1.5 volts, 3 ma. This circuit supplies operating power to the 100-kcps oscillator and the 100-kcps amplifier-detector.



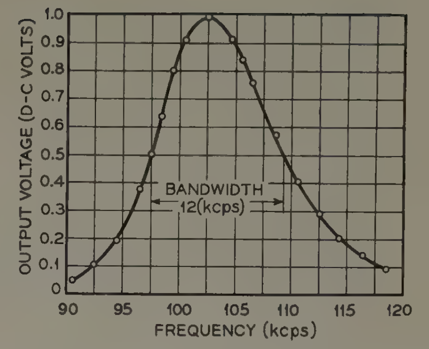


Fig. 5 (left). Frequency response of high-pass filter. Fig. 6 (right). Frequency response of transistorized 100-kcps amplifier-detector

OPERATING PROCEDURES

THE external controls and connections on the alpha-versus-I_e plotter are as follows:

1. Two sockets for test transistors, one for the Western Electric type and one for the conventional type.
2. Output to an oscilloscope for alpha indication.
3. Output to an oscilloscope for emitter current indication.
4. A power switch and a pilot light.
5. A control for adjusting the magnitude of the emitter sweep current.
6. A control for adjusting the d-c collector voltage.
7. A meter which indicates the d-c collector voltage and also serves to calibrate the emitter current on the oscilloscope.
8. A switch giving four ranges of emitter current magnification on the oscilloscope.
9. A switch used for calibration of alpha and the emitter current.
10. An output to be used for blanking of one of the traces on the oscilloscope.

In addition to these controls, an internal control is used to adjust the output voltage of the 100-kcps oscillator. This control should be set so that the voltage from the high side of the 1-megohm emitter-current resistor is 1 volt. Once this is set no change should be necessary unless the transistor in the oscillator circuit is changed.

After the test set has been allowed to warm up, the oscilloscope may be calibrated for emitter current by setting the emitter sweep range switch at 1 and the calibrate switch at *Calibrate* I_e. The emitter current (d-c) is read directly on the panel meter and may be adjusted with the V_c *Adjust* control. The oscilloscope controls should be set to give a deflection of 1 inch for a current of 1 milliampere. Various values for the emitter sweep deflection can then be obtained without recalibration by use of the emitter sweep range selector switch.

The alpha calibration may be made by setting the calibrate switch to *Calibrate Alpha* and setting the oscilloscope controls to give the desired deflection for an alpha of unity.

The calibrate switch should be returned to the *Read* position and the transistor to be tested may be inserted in the proper socket. The emitter sweep current should always be set as low as possible to cover the desired range so as to obtain the best response from the amplifier-detector circuit. To avoid the danger of damage to the test transistor, both the emitter current and the collector voltage controls should be returned to the minimum positions before inserting or removing the test transistors. Also, it should be noted that whisker transistors using *p*-type semiconductors or *n-p-n* junction transistors cannot be measured with this set without reversal of the polarities of the collector and emitter supplies.

CONCLUSIONS

A TEST set is described for displaying a plot of alpha versus emitter current on an oscilloscope. This instrument is useful in the application of point-contact transistors in large-signal switching circuits.

Alpha, the a-c short-circuit amplification, can be exhibited graphically as a function of emitter current and collector voltage with a small test set consisting of:

1. 100-kcps emitter-signal current-generator.*
2. 33-cps emitter-bias-sweep-current generator.
3. A high-pass filter.
4. A 100-kcps amplifier (gain 50 db, bandwidth 12 kcps).*

Appendix

PARTS LIST FOR ALPHA PLOTTER

1	Chassis and sloping front panel 8 by 14 by 8 inches
1	0–3 ma d-c meter 3 by 3 inches
1	Pilot light
2	*UG290/U BNC* jacks
5	Switch and potentiometer knobs
1	Set of labels
4	Coil shields $1^1/_2$ by $1^1/_2$ inches in diameter

* Transistorized.

SWITCHES

1	Dpst Toggle
1	1-circuit, 4-position ns
1	6-circuit, 3-position ns (Mallory *1323L*)

TUBES

1	*6X4*
1	*6AQ5*
1	*12AT7*

DIODES AND TRANSISTORS

4	Junction transistors *GE 2N34*
1	*GE 1N91*
2	*GE 1N70*
4	*GE 1N63*

SOCKETS

4	7-pin miniature tube
1	9-pin miniature tube
4	5-pin subminiature tube
1	Western-Electric-type transistor socket

TRANSFORMERS

1	Stancor *P6119*
1	Stancor *A3871*

COILS AND R-F CHOKES

1	1.0 mh (*B6*)
1	1.53 mh (*B5*)
1	2.06 to 2.60 mh (*B4*)
2	2.45 mh (*B1*)
1	9.6 mh (*B7*)
2	43 mh (*B2*)
1	2 section 300-turn and 700-turn No. 36 wire wound on 3/8 inch slugtuned ceramic form (*B3*)

CAPACITORS

1	20–20 μfd 450-volt electrolytic
4	50 μfd 25-volt electrolytic
1	25 μfd 25-volt electrolytic
3	10 μfd 150-volt electrolytic
2	4 μfd 25-volt electrolytic
1	1 μfd 400-volt paper
3	0.1 μfd 400-volt paper
1	0.06 μfd 400-volt paper
5	0.01 μfd disk
2	6,800 μfd mica
2	5,100 μfd mica
1	3,300 $\mu\mu$fd mica (approximately)
3	1,000 to 1,500 $\mu\mu$fd mica (depending on exact coil values)
2	1,000 $\mu\mu$fd mica
1	470 $\mu\mu$fd mica
1	330 $\mu\mu$fd mica

POTENTIOMETERS

1	500-K 1/2-watt
1	30-K 1/2-watt
1	1-K 3-watt

RESISTORS

1	1-M 1/2-watt
1	120-K 1/2-watt
1	100-K 2-watt
1	100-K 1/2-watt
1	47-K 1/2-watt
1	33-K 1/2-watt
1	22-K 2-watt
1	22-K 1/2-watt
1	10-K 1-per-cent precision
3	10-K 1/2-watt
1	56-K 1/2-watt
1	5-K 1/2-watt
1	4-K 2-watt
1	3.75-K 1-per-cent precision
2	2.2-K 1/2-watt
1	1.5-K 10-watt
4	1-K 1/2-watt
1	1-K 1-per-cent precision
1	680-Ω 1/2-watt
1	500-Ω 1-watt
1	270-Ω 2-watt
1	200-Ω 1-per-cent precision
2	100-Ω 1/2-watt
1	50-Ω 1-per-cent precision
1	33-Ω 1/2-watt

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X-Ray Microscope Magnifies Up to 1,500 Diameters

X rays are used to look inside all sorts of things, ranging from huge castings to the human body. Now scientists will soon have at their disposal a new General Electric Company instrument that will enable them to magnify and X-ray subjects which are smaller than the human eye can see.

Called the X-ray Microscope, the instrument was developed by the firm's General Engineering Laboratory, Schenectady, N. Y. It will be produced, after further refinements in design, by the company's X-ray Department in Milwaukee, Wis.

Capable of wide use in medical science, biology, and industry, the device magnifies up to 1,500 diameters and permits the study of grain structure in metals, the cell structure of bones and human tissue, the internal organs of tiny insects, and of various other subjects which are opaque to light.

Scientists in the laboratories of the United States and European countries have long endeavored to develop a practical device of this kind that can be produced in quantity. The principal feature of the G-E instrument is an electrostatic lens system that provides an X-ray source 300 times smaller than a human hair. This is important because the larger the X-ray source, the lower the potential magnification of specimens.

A conventional X-ray source cannot be made smaller than about 1/8 inch in diameter, and even a source as small as one 1,000th of an inch gives magnification no greater than that which can be provided by an ordinary reading glass.

The Effect of Frequency and Voltage on Equipment

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THE effect of low frequency and low voltage on power plant equipment, as well as on residential consumers' equipment during periods of trouble on power systems, is considered in this paper.

In the operation of the Pennsylvania–New Jersey Interconnection there have been occasions of low frequency. This low frequency was caused by the loss of major transmission lines which left an isolated area short of generating capacity.

The operating personnel, concerned about this low frequency, asked how low the frequency could drop before a generating station would be forced off the line by a reduction in the output of the station auxiliaries. Tests were conducted on two Philadelphia Electric Company stations to duplicate low-frequency conditions. These tests were conducted at Station *A* which is thermal, and at Station *B* which is hydro.

At each of these stations there is a separate house generator, so that the frequency of the supply to the auxiliaries can be varied.

Station *A* was able to carry full load with a 15-per-cent reduction in frequency and a 13-per-cent reduction in voltage. The limiting factor was the discharge pressure on the boiler feed pumps, although the induced draft fans were also approaching the danger point.

Station *B* was able to carry full load with a 12.5-per-cent reduction in frequency, and an 8-per-cent reduction in voltage. This test indicated that the limiting factors would be the governor oil-pump motor and the generator excitation supply; however, these limits had not been reached under the test conditions.

The results of the test at Station *A* were distributed to the other steam generating stations in Philadelphia Electric Company with the request that the test data be used to analyze their equipment wherever possible. The design characteristic curves of Station *A* auxiliaries were compared with the characteristic curves of other station auxiliaries. The effect of frequency and voltage on the other steam generating stations' reliability and capacity was determined as follows:

Station	Capacity at Various Frequencies: 60 Cycles	57 Cycles	54 Cycles
C	180	180	180
D	252	249	242
E	436	436	424
F	467	467	466
G	184	181	175
A	364	364	364
B	252	252	252
Total	2,135	2,129	2,103

It was concluded that with 10-per-cent reduction in frequency, Philadelphia Electric Company capacity would be reduced 1.5 per cent.

Manufacturers recommend only a ±3-per-cent change in frequency as a safe limit for turbines. The determining factors involved are rotor critical speed, resonant blade frequencies, water gland runner and oil-impellor performance, and coupling torque. The most critical item relates to blade frequency.

This study indicated that in time of system trouble the Philadelphia Electric Company system could operate at a frequency 10 per cent below normal without serious consequence to equipment, except for the possible damage to blading while passing through critical speeds. Since turbine manufacturers' limit is 3-per-cent drop in frequency in order to safeguard the turbine blading, this study confronts the power companies with one major question: Should load be dropped at 58.2 cycles to protect blading, or should possible damage to equipment be risked to maintain continuity of service to the customers?

Tests were conducted at a local college with different combinations of appliances. The circuit was arranged to give power factors of 83, 95, and 99 per cent. At the 83-per-cent power-factor load and a constant 60-cycle frequency, the watts decreased in almost direct proportion with voltage. When the appliances were operating at reduced frequency the watts decreased in greater proportion with voltage.

A television set was placed on test at 55 cycles by a local manufacturer. A slight hum in the set was noticed with a slight weave through the picture. The sides moved in one-eighth of an inch, and no excess heating was experienced during the test.

Motor manufacturers' standards for small motors are 10-per-cent voltage variation or ±5-per-cent frequency variation, with a combination of voltage and frequency of ±10 per cent for unlimited time.

This study indicated that small motors and appliances could operate satisfactorily when there is a 9-per-cent reduction in frequency and a 10 per cent reduction in voltage.

The effect of frequency and voltage on system load demand cannot accurately be determined in the laboratory, unless the proportion of different types of load is known. It would be necessary for each power system to conduct an actual test on its own system to determine this effect on frequency and voltage.

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Digest of paper **54-390,** "The Effect of Frequency and Voltage," recommended by the AIEE Committee on System Engineering and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1954.

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480 Wye/277-Volt Power System in Telephone Building at Menands, N. Y.

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A comprehensive evaluation and cost comparison between 480 wye/277- and 208 wye/120-volt power system is given for a modern building having a load of several kva or over.

THERE is an increasing tendency for the modern commercial building to employ voltages above the conventional 208 wye/120 volts. This has been increasingly true for new buildings with a load of a few thousand kva or above.[1] For these buildings, the distribution voltage has been 480 wye/277 volts with a substantial portion of the utilization at this voltage. These loads include lighting, air-conditioning motors, elevator and other service machinery, and motor-pump sets.

A small building, with a load of less than 1,000 kva, has proved to be more economical at 480 wye/277 than at 208 wye/120 volts in a number of cases. One such case is the Twin Falls High School at Twin Falls, Idaho.[2]

The purpose of this article is to make available the results of the economic studies at the two voltage levels and to show the effect of conventional 120-volt switching in comparison with 24-volt remote-control branch-circuit switching. Two conclusions resulted: a revaluation of the branch-circuit wiring to the effect that it is a relatively minor part of the system for the building; and the flexibility of a master control switching system takes on more importance than first realized.

The rectangularly-shaped brick-veneered office building is 102.5 feet by 248.5 feet. With each floor having 25,470 square feet gross, the total area for the building becomes 76,410 square feet gross. The three floors are similar in design, the individual offices being provided with movable metal partitions. Fluorescent lighting is supplied by 8-foot slimline tubes. Incandescent lighting, operating at 120 volts, is used in the cafeteria and other isolated areas.

BASIS FOR SYSTEM STUDIES

IN choosing the 480 wye/277-volt power system for the new telephone building, a very careful review was made of the economic and engineering features of supplying power by using: 1. a 480 wye/277-volt system with 24-volt remote-control switching; 2. a 208 wye/120-volt system with 24-volt remote control switching; and 3. a 208 wye/120-volt system with regular 120-volt switchings.

One of the first steps in comparing the choice of using a secondary voltage level of 480 wye/277 or 208 wye/120 volts is to itemize the loads in the building. Because the loads would all be at 120 volts within a 208 wye/120-volt system, with the exception of the elevator and ventilating motors which would be 208 volts, 3 phase, the loads are itemized in Table I for the 480-volt system only.

Table I. Loads for 480-Volt System

	Kilovolt-Amperes	Per Cent
120-volt		
Kitchen equipment	18	
Boiler room equipment	30	
Lighting incandescent	40	
Office machines (estimated)	182	
Total kva	270	54.6
480-volt		
Elevator	10	
Ventilating motors	26	
Total kva	36	7.2
480 Wye/277-volt lighting		
Total kva	190	38.2
Building kva	496	100.0

The lighting load represents about 3.0 volt-amperes per square foot, including both the fluorescent and incandescent lighting, against the 120-volt office machines at 2.4 volt-amperes per square foot, and all the remaining loads in the building at 1.1 volt-amperes per square foot.

Based on past generalizations, it may be thought that a 480 wye/277-volt system would not be more economical than a 208 wye/120-volt system for a small building such as this in which more than half the load must operate at 120 volts. The general application of a 480-volt system for small buildings is discussed in more detail in the conclusions of the article. The results of the comparisons that follow show that the 480 wye/277-volt distribution can be more economical for a small building with only a few integral-horsepower machines and having a 120-volt load as high as 54.6 per cent of the total.

Note that this telephone building does not include air-conditioning equipment of any kind. If it had been included as a centralized air-conditioning equipment, it would have increased the load and could have used motors rated 440 volts. This would most certainly make the 480 wye/277-volt system even more economical because the percentage of 480-volt load would be higher.

Louvre brightness was controlled by employing matte aluminum reflectors.

A paper, 1 of 11 in special publication *S-66*, recommended by the AIEE Transmission and Distribution and Industrial Power System Committees and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Published in AIEE *Applications and Industry*, November 1954.

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INSTALLED COSTS

Although the cost of materials, such as lighting fixtures, cables, or substations, is lowest for the 480 wye/277-volt system, an evaluation based on equipment cost only would be inconclusive for a study such as this. A preferred and a more representative comparative base is installed cost. Previous studies[3] were also made on the basis of installed cost. These studies omitted items related to the electric system such as the underfloor duct system, lights and fixtures, and the actual first cost of machines, but did include the effects of such items. This article gives the additional information for the sake of completeness.

The system cost comparisons are based on sound system engineering. It should be noted, however, that local codes, type of building construction, and other factors may alter the engineering choice of equipment and the total installed cost for a similar building in other localities. One of the National Electrical Code requirements enforced for this building was the required use of asbestos wire to make direct connection to the fluorescent fixtures. This and other points dealing with codes are covered in detail later.

Fig. 1. Typical panelboard layout during construction. The electric services are in the box at the left, and the telephone and signal circuits are handled in the two boxes to the right

INCOMING 4,160-VOLT SERVICE

A single 4,160-volt service was made available from the local utility. Their service terminated at the utility pole and the telephone company supplied the cable service to their metal-clad switchgear equipment, which consisted of an entrance compartment for the power company's metering, a second compartment containing the control power transformer, and a third compartment containing a single magne-blast power circuit breaker, rated 4.16 kv, 150 megavolt-amperes interrupting, 1,200 amperes, and using a-c close and d-c trip from a 24-volt battery.

Four single-conductor no. 4/0 5-kv Super Coronol* cables are used to connect between the metal-clad switchgear and the unit substations. These services are terminated at the load center primary Pyranol* filled switches. Provision has been made for connecting additional substations to this 4,160-volt cable service. The fourth wire, neutral ground wire, is terminated on the ground pad of the load center substation transformer. The neutral is presently disconnected at the utility pole. It is hoped that the connection of this neutral wire to the utility system will soon be made. This will decrease the zero phase sequence impedance to assure a proper and low impedance ground return of ground-fault current through this return neutral wire instead of forcing it through a building structure or piping, should a fault occur in one of the transformers.

The two load center unit substations are located on the first floor and have a normally open secondary tie to form a "secondary selective" system. This type of system is very adaptable to commercial buildings supplied at primary voltage and is being increasingly specified. This arrangement permits one of the substation transformers to be removed from service for routine maintenance. By closing the tie circuit breaker, the other transformer can supply the essential loads on both substation busses to keep power available everywhere in the building. This system provides a high order of safety because the switching, for transferring load, is handled on the secondaries by an adequate circuit breaker.

SYSTEM A: 480 WYE/277 VOLTS, 24-VOLT SWITCHING

The 300-kva load center unit substation, rated 480 wye/277 volts secondary, uses a main circuit breaker rated 25,000 and feeder breakers rated 15,000 asymmetrical amperes interrupting.

Panelboards. Convenience necessitated the use of two panelboards to serve one-third of each floor. The telephone company required each panelboard location on a floor to be served by one feeder. Therefore, a separate feeder serves one panelboard on each of the three floors, or three panelboards per feeder. This required each of the two substations to have three feeder breakers for lighting and office machines, and one feeder for special services.

The various panelboards making up the panelboard layout are shown in Figs. 1 and 2. The composite Trum-

Fig. 2. Electrical services in the panelboard on the left, which has 277-volt fused circuit (left), transformer secondary breaker for 120-volt transformers (top), and 120-volt circuits (right)

* Registered trade-mark of General Electric Company.

Fig. 3. Ceiling of one section showing the 277-volt circuiting to the conduit box for fluorescent fixture and the split conduit box for the 24-volt control

bull panelboard on the left of the layout contains the switching for the electric services. This panelboard contains three parts: 1. the right-hand section houses the small 120-volt molded-case breakers for protecting the 120-volt circuits; 2. the bottom section houses the molded-case breaker on the secondary side of the three single-phase dry-type *M*-transformers—generally three 15-kva units—which feed the 120-volt molded-case breakers; and 3. the left-hand section houses a Swing-wa* panelboard which uses silver-sand current-limiting fuses. This fuse-switch combination has been successfully tested to 50,000 asymmetrical amperes short-circuit current.

277-Volt Branch Circuits. The branch circuits for one-third of a floor terminate at special conduit boxes which contain the 24-volt control relays. This is illustrated in Fig. 3, showing the ceiling before completion.

24-Volt Remote-Control Switching. It is easily seen that this system includes a transformer to supply control power at 24 volts for use on the control switches, remote-control relays, and small 24-volt wall switches for each circuit. As well as permitting only 24 volts to be within the reach of the building occupants, this system offers outstanding advantages for office buildings, since it is extremely flexible, convenient to install, safe to operate, and makes a substantial saving in the over-all system cost possible.

Fig. 4. Typical master control switching center, each of which controls over one-third the lighting

In Table II it is shown that the total cost of materials and labor for the 24-volt remote-control switching was \$2,940, whereas for the 120-volt switching it was \$5,112, as seen in Table IV. It is a common misconception that 120-volt switching is less expensive than the 24-volt remote-control switching system. The ratio of the total installed cost for the master switch control system using 120-volt switching and 24-volt remote-control switching was 2.6 to 1, a difference of over \$13,000.

SYSTEM B: 208 WYE/120 VOLTS, 24-VOLT SWITCHING

The 300-kva load center unit substations, when operating at the lower secondary voltage of 208 wye/120 volts, will have approximately twice the available short-circuit duty as at 480 wye/277 volts. This requires increasing the interrupting rating of the main circuit breaker to 50,000 and the feeders to 25,000 asymmetrical amperes.

Panelboards. The locations of the panelboards are positioned similarly to those used in the 480 wye/277-volt system. Only one 208 wye/120-volt panelboard is required instead of the split panelboard for the 277- and 120-volt services, as is necessary for the 480 wye/277-volt system. This permits thermal molded-case breakers to be used in the panelboard for protecting all the branch circuits. The number of lighting circuits increases from system *A* to *B* in the ratio of 2.1 to 1. The ratio of the two system voltages of 277 and 120 volts is 2.3 to 1. An examination of systems *A* and *B*, Tables II and III, will immediately show that the panelboards are less expensive for system *A* than for system *B*. In addition, the 480–120-volt dry-type transformers should be included with the 480 wye/277-volt system to obtain a true cost comparison. The 480 wye/277-volt system is penalized in this part of the system installation principally because of the added cost for dry-type transformers. This is of minor importance when compared with the substantial savings made in the substations, secondary feeders, and branch-circuit switching.

24-Volt Remote-Control Switching. The 24-volt remote-control switching, for the 480 wye/277-volt system is identical to that for the 208 wye/120-volt system. The only change for 120-volt lighting would be to change the actual power services from 277 to 120 volts. A comparison of Tables II and III will show that the column switch control and the master switch control should be, and are, identical.

SYSTEM C: 208 WYE/120 VOLTS, 120-VOLT SWITCHING

The 300-kva load center unit substations are identical to those used in system *B*.

Panelboards and Branch Circuits. Systems *B* and *C* have

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identical panelboards. The typical method of running branch circuits to the 120-volt fixtures, is again identical for systems *B* and *C*.

120-Volt Switching. An examination of Table IV indicates that 2.4 per cent of the system cost, based on 480 wye/277-volt system cost as 100 per cent, is in the column switch control with 120-volt switching whereas it is only 1.3 per cent in Table II or III when the column switch control used the 24-volt remote-control system. The 24-volt remote-control system not only costs less in this case but also provides substantial benefits in the way of flexibility and safety over the common 120-volt branch-circuit switching.

Table II. System A: 480 Wye/277 Volts with 24-Volt Switching

	Material	Labor	Total	Subtotal	Dollars per Kilovolt-Ampere	Per Cent of Total
Primary feeders	$ 2,393.72	$ 581.88	$ 2,976		5.0	1.4
Two 300-kva substations	28,572.24	2,754.50	31,327		52.2	14.3
Secondary feeders	2,083.52	1,051.15	3,134		5.2	1.4
480-120-volt transformers: fifteen 15-Kva, three 10-Kva	5,474.02	1,267.07	6,741		11.2	3.1
				$44,178	73.6	20.2
Panelboards	8,871.00	1,731.89	10,603		17.7	4.9
Lighting branch circuit	5,256.11	10,063.73	15,320		25.5	7.0
Receptacle, etc., branch circuits (120 volts)	3,445.60	4,510.50	7,956		13.3	3.6
				$33,879	56.5	15.5
Underfloor duct system	46,145.94	10,921.61	57,068		95.1	26.1
Motor wiring and equipment	3,398.05	1,694.94	5,093		8.5	2.3
Telephone and signal system	727.00	688.63	1,416		2.4	0.7
Telephone and signal cabinets	1,801.91	237.57	2,039		3.4	0.9
Miscellaneous, hangers, pullboxes, etc.	2,250.68	346.97	2,598		4.3	1.2
				$68,214	113.7	31.2
Fluorescent and incandescent fixtures and lamps	61,031.71	8,273.84	69,305		115.5	31.8
Column switch control	1,228.48	1,711.66	2,940		4.9	1.3
				$72,245	120.4	33.1
Total	$172,679.98	$45,835.94	$218,516		364.2	100.0
Master switch control (24-volt)	3,570.68	5,889.09	9,460		15.8	4.3
			$227,976		380.0	104.3

Table III. System B: 208 Wye/120 Volts with 24-Volt Switching

	Material	Labor	Total	Subtotal	Dollars per Kilovolt-Ampere	Per Cent of Total (on 480-Volt Base)
Primary feeders	$ 2,393.72	$ 581.88	$ 2,976		5.0	1.4
Two 300-kva substations	39,698.15	3,213.59	42,912		71.5	19.6
Secondary feeders	6,441.67	2,076.21	8,518		14.2	3.9
				$54,406	90.7	24.9
Panelboards	9,925.65	2,398.90	12,324		20.5	5.6
Lighting branch circuits	6,390.00	12,210.00	18,600		31.0	8.5
Receptacles, etc., branch circuits	3,446.60	4,510.50	7,956		13.3	3.7
				$38,880	64.8	17.8
Underfloor duct system	46,145.94	10,921.61	57,068		95.1	26.1
Motor wiring and equipment	3,398.05	1,694.94	5,093		8.5	2.3
Telephone and signal system	727.00	688.63	1,416		2.4	0.7
Telephone and signal cabinets	1,801.91	237.57	2,039		3.4	0.9
Miscellaneous, hangers, pullboxes, etc.	2,250.68	346.97	2,598		4.3	1.2
				$68,214	113.7	31.2
Fluorescent and incandescent fixtures and lamps	59,890.59	8,273.84	68,164		113.6	31.2
Column switch control	1,228.48	1,711.66	2,940		4.9	1.3
				$71,104	118.5	32.5
Total	$183,738.44	$48,866.30	$232,604		387.7	106.4
Master switch control (24-volt)	3,570.68	5,889.09	9,460		15.8	4.3
			$242,064		403.5	110.7

ECONOMIC COMPARISONS

The detailed breakdowns of the costs for the three systems studied are given in Tables II, III, and IV. Included are material, labor, total installed cost, dollars per kva, and per cent of each item using the 480 wye/277-volt system cost as a base of 100 per cent. Items in all three tables having the identical installed cost, in dollars, will be the same per cent of total cost.

These three tables group material and labor into four subtotal listings. The first deals with the incoming service, the substations, and secondary feeders. It can be seen that there is an advantage for the 480 wye/277-volt system over system *B* and *C* of $17.1 per kva. The second grouping, including the panelboards and the branch circuits for both lighting and receptacles, shows an advantage for system *A* over *B* of $8.3 per kva, and for system *A* over *C* of $13.2 per kva. The third grouping lists identical items, and particular attention should be given to the very large, 26.1-per-cent, portion of the system required for the underfloor duct system. It should be emphasized that the underfloor duct system is much less expensive in the long run than other systems where it is necessary to modify branch-circuit wiring in the floor or ceiling. The next group deals with the lighting fixtures and column switch control. The difference in the latter has been discussed previously. The only difference in the two figures, at 277 and 120 volts, for the fluorescent lighting is about $1.60 in favor of the 120-volt ballast. It is the authors' opinion that this difference will disappear with the increased use of the 480 wye/277-volt lighting system, as there is no engineering reason why 277-volt ballasts should cost more than 120-volt ballasts.

The most important item to compare is the total cost for all material and labor. Here system *A* proves to be $23.5

per kva less than system B and \$32.0 per kva less than system C. It is important to note that system C is \$8.5 per kva more than system B. The difference between system B and C comes from only two sources: the increase in lighting branch circuits, and column switch control. Although it is certainly not a practical comparison, the difference between systems A and C, when including the master switch control system, is \$57.6 per kva.

PROBLEMS RESULTING FROM ELECTRICAL CODES

Article 210, section 2113, entitled "Branch Circuits," of the National Electrical Code[4] deals with "Voltage." The 1953 revision of this Code states that, "Branch circuits supplying lamp holders, fixtures, or receptacles of the standard 15-ampere or less rating" can be from 150 to 300 volts to ground "in industrial establishments, office buildings, large schools and stores," providing the ballasts for permanently installed fixtures be "mounted not less than 8 feet from the floor," and "do not have manual switch control as an integral part of the fixture(s)." This requirement of the National Electrical Code has been completely adhered to in the telephone building.

Additional safety has been provided in this building, beyond the requirements of most codes, in that all the branch-circuit switching throughout the building, whether the line-to-neutral voltage is 277 or 120 volts is handled by 24-volt switches.

The New York Telephone Company has had extensive experience in constructing and operating buildings throughout New York State. Many of these new buildings have used recessed fixtures for fluorescent lighting. Section 94105 of the Code[4] deals with "Flush and Recessed Fixtures" and requires, under item *f* "Conductor Insulation," that the "Recessed fixtures shall be wired with AF or AI fixture wire." The local inspector had always waived this requirement for recessed fluorescent fixtures provided adequate means for cooling the fixture are incorporated in the ceiling construction. An identical construction was employed in this building as in many others, but because this was the first building to apply the 480 wye/277-volt lighting system in an office-type building in the Albany area it was believed that conservatism demanded that this requirement be fulfilled exactly. It is appropriate to add that the design of the fluorescent fixtures prohibits easy access to the fixture by its dead-front construction. The vast experience in industrial plants[5] with 277-volt lighting indicates that the added expense of using asbestos wire, at either 277 or 120 volts, is not required from a safety or engineering standpoint.

REMOTE-CONTROL SYSTEM

The building maintenance foreman at this building, after less than two weeks' observation, made the statement, "This is the only building I ever heard of where the lighting control system was designed with the maintenance people in mind." A source of constant irritation for maintenance people is the recurring observation by top management that buildings use too much light at night. The management point is always well taken, but the means for effective and economical control of the problem is seldom placed in the maintenance department's hands. In this installation, master switch control has been furnished at three locations per floor. Each half-floor has complete remote control from the north and south staircases and each full floor is controlled at the center staircase, see Fig. 4. Therefore, it is easy to turn all the lights off and on from these locations without walking over the entire floor.

Cost of Relay Conduit Boxes. Included in Tables II and III, under "lighting branch circuit," is the cost for individual conduit boxes housing the remote-control relays. These relays are located in the ceilings along the branch-circuit runs and near the column switches. The deletion of the 252 individual relay boxes and the relocation of the 252 relays in 18 relay boxes, one at each panelboard location, was also studied. The cost was 252 boxes×\$6.32 per box=\$1,593; 18 boxes×\$30 per box=\$540. Therefore, the apparent saving=\$1,053.

The use of the 18 relay boxes would involve extension of the 24-volt wiring and conduits from the 252 ceiling relay locations to the panelboard locations at a cost equal to or exceeding the \$1,053 previously mentioned. Applying a motor-operated master control switching system, such as the General Electric "Circuit Servant" plan, to the 18

Table IV. System C: 208 Wye/120 Volts with 120-Volt Switching

	Material	Labor	Total	Subtotal	Dollars per Kilovolt-Ampere	Per Cent of Total (on 480-Volt Base)
Primary feeders	\$ 2,393.72	\$ 581.88	\$ 2,976		5.0	1.4
Two 300-kva substations	39,698.15	3,213.59	42,912		71.5	19.6
Secondary feeders	6,441.67	2,076.21	8,518		14.2	3.9
				\$54,406	90.7	24.9
Panelboards	9,925.65	2,398.90	12,324		20.5	5.6
Lighting branch circuits	8,215.74	13,304.34	21,520		35.9	9.9
Receptacles, etc., branch circuits	3,446.60	4,510.50	7,956		13.3	3.7
				\$41,800	69.7	19.2
Underfloor duct system	46,145.94	10,921.61	57,068		95.1	26.1
Motor wiring and equipment	3,398.05	1,694.94	5,093		8.5	2.3
Telephone and signal system	727.00	688.63	1,416		2.4	0.7
Telephone and signal cabinets	1,801.91	237.57	2,039		3.4	0.9
Miscellaneous, hangers, pullboxes, etc	2,250.68	346.97	2,598		4.3	1.2
				\$68,214	113.7	31.2
Fluorescent and incandescent fixtures and lamps	59,890.59	8,273.84	68,164		113.6	31.2
Column switch control	3,120.23	1,992.26	5,112		8.5	2.4
				\$73,276	122.1	33.6
Total	\$187,455.93	\$50,241.24	\$237,696		396.2	108.9
Master switch control (120-volt)	13,849.00	10,980.00	24,829		41.4	11.3
			\$262,525		437.6	120.2

panelboard locations would simplify and reduce the cost of the installed master switch wiring, but would add some $1,100 to the apparatus cost and would impair the selectivity of the system.

CONCLUSIONS

This article gives a comprehensive evaluation and complete cost comparison between 208 wye/120- and 480 wye/277-volt power systems for an office building. It shows that even for this small building, with 54.6 per cent of its load at 120 volts, it is $23.5 per kva less at 480 wye/277 volts than at 208 wye/120 volts with comparable switching. It also shows a saving of $32.0 per kva between the 480 wye/277-volt system with 24-volt switching and 208 wye/120-volt system with 120-volt switching. The cost data were substantiated by hiring a consulting engineer to make complete drawings for the cases studied, and an electrical contractor to obtain bids on all equipment.

Now that 277-volt wall switches are available, it is possible to add a fourth comparison which would be a 480 wye/277-volt system with 277-volt switching. One thing is clearly evident about its application from the tables in this article. Table II would be very similar and would only have variations in the lighting branch circuits and column switch control, as Table IV differs from Table III. The important point is that although the 24-volt switching would be more economical than 277-volt switching, the over-all economy of the 480 wye/277-volt system would not be affected adversely by the use of 277-volt switches.

Emphasis is again placed on the flexibility that must be incorporated in the modern commercial building. A detailed economic evaluation was not made in comparing the 24- and 120-volt master switch controls. One point in favor of 24-volt switching is, that in providing movable partitions used to form office areas, the changes in 24-volt switching control can be made easily and in a comparatively inexpensive manner by simply running the control wire in the underfloor duct, within conduit or wire mold or even exposed. This is much easier to do than for the larger power-carrying services, and reduces the cost of making future changes.

It is important to mention that the relative difference in dollars per kva between the 480 wye/277- and 208 wye/120-volt systems would be larger had this same size building been air-conditioned. Experience indicates that a building, in this locality, would approximately double its load if it were entirely air-conditioned. This air-conditioning equipment would use an integral-horsepower motor rated 440 volts. The increase in load at 480 volts would produce a greater difference in dollars per kva between the 480 wye/277- and 208 wye/120-volt systems. Even if small unit air conditioners were used, the increase in motor load could more easily and economically be supplied from a 480-volt system. In fact, it can be said that as the load grows in the modern commercial building using fluorescent lighting, more economical operation and lower first cost can be expected if the 480 wye/277-volt system is selected.

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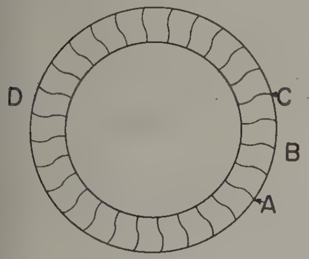
Electrical Essay—Induced Electromotive Force

Maxwell's equations for the electromagnetic field are commonplace to every student of electricity. Nevertheless, the discussions between Alter Ego Slepian and his friends Jack and Bill (February 1951, p. 159) revealed fundamental cases where the physical meaning of conclusions to which these equations lead is anything but commonplace. I feel that the following example deserves to be added.



Some time ago I put this question as a kind of riddle to Fred, a well-instructed engineer. Assume an annular iron core with two windings all along the core; the one (primary) being open, the other (secondary) being closed. There is perfect symmetry except for the terminals of the open winding through which alternating current with the amplitude of i is transmitted. A voltmeter with practically infinite resistance is connected at A and C on the secondary winding. The resistance from A over B to C is r. And the question is, what voltage will the voltmeter measure?

Fred smiled and answered that, since the voltage ri is needed to overcome the resistance r, he expects the voltmeter to indicate a voltage amplitude of ri. "Why not the bigger value Ri," I said, "where R is the resistance in CDA?"

Actually, in the case of perfect symmetry, no electric tension is indicated by the voltmeter. And the reason for this is, because of symmetry, the density of the current carrying electrons is constant all along the secondary winding, i.e., no space charges are generated. The voltmeter would react only if the density of the electrons would differ in A and C, as in the case when the secondary winding is cut open at B.

"The moral," concluded Fred, "is that the term 'electric tension' should be reserved for voltages which are produced by electric charges." The current in the secondary winding is driven by an electromagnetic force without any help of electric attraction or repulsion.

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Characteristics of the High-Current Argon Arc

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A CAREFUL and precise study of a controlled arc in a current range of 25 to 100 amperes is described in this article. The study was made to obtain a quantitative picture of the effects on the arc produced by the electrode materials and the gas in which the arc burns. Argon was chosen as an atmosphere rather than air to simplify conditions by eliminating chemical reactions between the gas and the electrodes, and by presenting the effects of one gas rather than a mixture of gases. The electrode materials were tungsten, tantalum, molybdenun, titanium, iron, and copper, chosen to give a wide variety of properties.

The study was carried out in an arc chamber which could readily be evacuated to 1-micron pressure before filling so that a high degree of gas purity could be maintained. The prime experimental problem was to secure reproducible results. This was accomplished by setting up a specific procedure for preparing the electrodes and by employing a set of coils which produced a coaxial magnetic field of 500 gauss in the neighborhood of the arc.

Spectroscopic observations were made on the arc for the case where one electrode was tungsten and the other one was molybdenum, with a current of 50 amperes, and a 1/2-inch separation. Scrutiny of the plates showed that the gas and anode material lines were present throughout the entire discharge with a large increase of intensity for the gas lines directly in front of the cathode. In contrast, the cathode material lines showed up strongly in the cathode region but did not extend to the anode.

Voltage-current and voltage-arc length characteristics were taken for various combinations of electrode materials. All the *V-I* and *V-l* curves were similar in form to the ones shown for a tungsten cathode and iron anode in Fig. 1. The literature was searched for an equation to satisfy the curves; however, no satisfactory published equation was found. Careful examination of the data showed

$$e=a+bl+\frac{c}{I}+dI$$

depicted the experimental results over the entire range of 25 to 100 amperes. Furthermore, some measurements taken at 200 and 450 amperes indicated that the equation also held at these points. In the equation, l is the arc length, e the arc voltage, I the current, and a, b, c, and d are constants. A table was set up of these constants for the various electrode combinations used:

Tungsten Cathode in Argon

Anode	a Volts	b Volts/Inch	c Watts	d Ohms
Tantalum	3.8	12.0	255	0.074
Molybdenum	4.6	12.0	260	0.052
Iron	5.7	9.5	210	0.070
Tungsten	6.5	10.3	235	0.047
Titanium	7.6	12.5	186	0.049
Copper	9.5	11.5	194	0.029

Tungsten Anode in Argon

Cathode	a	b	c	d
Tungsten	6.5	10.3	235	0.047
Molybdenum	7.4	11.2	107	0.036
Tantalum	5.6	12.5	186	0.031

From this tabulation it was observed that the relative effects on the arc voltage of the different electrode materials is not as pronounced as the effect of different gases.

Measurements of anode melting for several materials showed that once melting starts the melting rate rises sharply from zero and then levels off quickly so that the material melted per coulomb is a constant over a wide current range. Calculation of heat input to the anode per coulomb from the melting rate and the heat of condensation per coulomb of electrons showed that the two were approximately equal. This condition suggested that the anode drop for the type of arc studied is zero or very small.

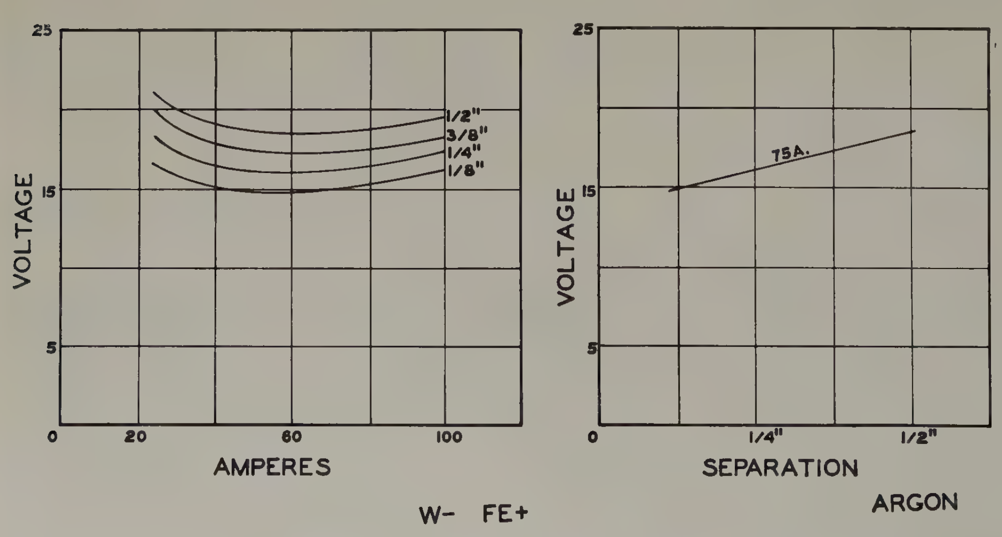

Fig. 1. V-I and V-l curves of an arc between a tungsten cathode and an iron anode. The electrode diameter is 1/4 inch and the arc lengths are as marked beside each V-I curve

Digest of paper 54-510, "Characteristics of the High-Current Argon Arc with Various Electrode Materials," recommended by the AIEE Committee on Basic Sciences and approved by AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Transistor Broadcast Receivers

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Portable transistor broadcast receivers of good quality can now be built with present experimental transistors. It is anticipated that such receivers will appear on the market as soon as transistors and other miniaturized components are available at reasonable prices.

DURING the past few years, the transistor has emerged from the laboratory and taken its place on the ever-increasing list of components available to the electronic engineer. The transistor is now accepted as an important and reliable tool and has been successfully applied to a number of commercial products.

Broadcast receivers and, in particular, portable receivers can benefit very materially from "transistorization." Transistors offer the possibilities of decreased size and weight, considerably more efficient battery operation, greater mechanical stability and indefinite life, to name a few.

Many engineers unfamiliar with transistors feel that "transistorization" of a broadcast receiver means little more than the replacement of tubes by transistors. This is very far from the truth. Although the block diagram of a receiver will be the same whether tubes or transistors are used, the design considerations related to the individual "blocks" and some "system aspects" will be quite different. Transistors have "natural" advantages and limitations which must be taken into account in order to achieve desirable over-all performance, simplicity of functions, and economical design.

Although one can state safely that transistors are here to stay, they will not stay in their present form. While certain transistor types have been developed and have proved adequate for numerous applications, new types and improved techniques for producing existing types are being introduced constantly. New semiconductor devices are being developed: transistor tetrodes, pentodes, double-base diodes, etc., and even restricting considerations to, say, junction triodes, it is only reasonable to assume that within a short time different types of this device will be developed for different applications. After all, who would build a receiver using only one kind of tube?

Consequently, in such a period of transition and rapid development, the description of a particular transistor receiver would not be of great significance. Rather, this article will concentrate on illustrating the principles of receiver component circuits and general aspects of the transistorized system. Complete circuit diagrams of some receivers actually built by the authors will also be shown. Because of the rapid strides being made in the art, however, a receiver is virtually out of date before it is completed. The complete receivers should, therefore, not be considered as being necessarily the best that could be designed today. They are included merely to give an over-all picture of how the various sections discussed separately might be combined to form a working receiver.

This article is based on the work of the authors and others in the Electronics Laboratory of the General Electric Company. The transistors used were General Electric point-contact and experimental *p-n-p* and *n-p-n* junction transistors, and the conclusions apply rigorously only to these devices, although most of them can be generalized to include many presently available transistors of other manufacturers.

Revised text of a paper presented at the 1954 National Convention, Institute of Radio Engineers, New York, N. Y., March 22–25, 1954, and recommended for publication by the AIEE Committee on Radio Communication Systems.

Parts of this article will be incorporated in a thesis to be presented to the Electrical Engineering Department of Syracuse University.

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The work of the authors has been made possible by the co-operation and encouragement of many individuals. Much of this work was based on the original investigations of Dr. W. F. Chow. The help and valuable advice of I. C. Abrahams, C. A. Aldridge, L. T. DeVore, J. S. Schaffner, R. F. Shea, and J. A. Worcester, all of the General Electric Company, are fully appreciated.

RECEIVER COMPONENT CIRCUITS

THE functions of the individual component circuits of a superheterodyne AM broadcast receiver are similar whether tubes or transistors are used. This section reviews briefly some of the problems related to the transistorization of these functions and shows corresponding transistor circuits.

Intermediate-Frequency Amplifier. The basic consideration governing the design of a transistor amplifier, whatever the frequency range in which it is to work, is that each stage amplifies signal power. Transistors are low-impedance devices and, therefore, draw power from the signal source. This power is amplified by the transistor and fed to a load, which may be a subsequent transistor.

In order to make full use of the available gain of the device, the generator impedance must be matched to the input impedance and the load impedance to the output impedance of the transistor. Since input and output impedances of the transistor are not equal, where two or more stages are cascaded, interstage impedance matching networks are desirable. In a high-frequency (i-f or r-f) amplifier, impedance matching between stages is essential because the maximum available gain of transistors is usually lower in this frequency range than at audio frequencies.

Transistor impedance levels depend on the d-c operating point, the signal frequency, the transistor type, and the particular configuration used. Typical values (for I_e= 1 ma, V_c=6 volts) in grounded emitter configuration at

455 kc are: 500 ohms for the input and 10,000 ohms for the output impedance. These values require an interstage impedance transformation of approximately 20 to 1. Both impedances have considerable reactive components. The reactive components are tuned out by interstage coupling networks.

The matched gain of the grounded emitter configuration exceeds that of the grounded base circuit at low and intermediate frequencies. Whether a given frequency is "low" or "high" depends on the transistor type used. With modern junction transistors having good frequency characteristics, it will be found that the difference is appreciable up to several megacycles. Consequently, the grounded-emitter configuration is usually preferred.

The two most important factors in the operation of the i-f amplifier are gain and selectivity. In order to make full use of the gain of an i-f stage, it is necessary to transfer almost the entire available output power of this stage to the next one. This means that only a small fraction of the power should be consumed by the coupling network between stages. In other words, the output impedance of the first and the input impedance of the next stage should dampen strongly the coupling network. Therefore, generally, the requirements concerning maximum gain and adequate selectivity are conflicting. In order to achieve both results, the "unloaded" Q's of the coupling circuits must be very high: values in excess of 150 are desirable. As these Q's should be realized with miniaturized coils, the use of high-quality ferrites is indicated. Loading of the tuned circuits by transistor impedances results in moderate "operating" Q's and reasonable bandwidth.

Various coupling circuits can be used and some are shown in Fig. 1. The gain of transistors being lower than that of tubes, more transistors than tubes are required for

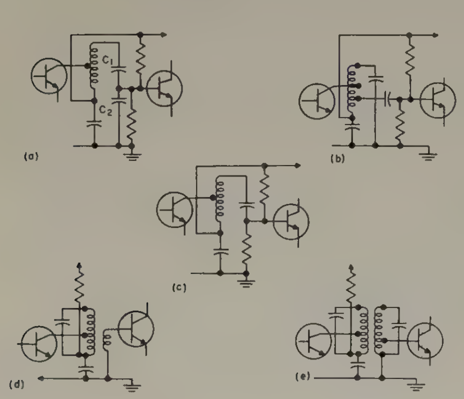


Fig. 1. Various interstage coupling networks

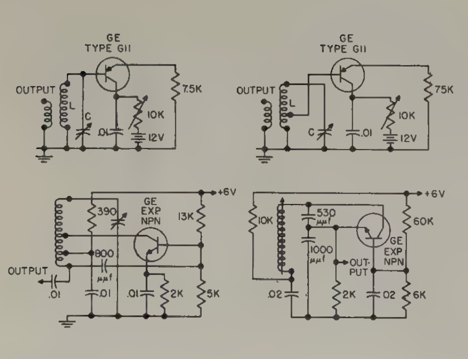


Fig. 2. Oscillators: *Negative resistance point-contact oscillators (above); Junction-transistor oscillators (below)*

comparable performance. Consequently, single tuned circuits may be used as interstage coupling networks without deterioration in selectivity.

The transistors are usually connected across only a portion of the tuned circuit; this technique results in better Q's with reasonably priced wire, reduces the dependence of the tuning on varying transistor parameters (due to shifts in operating point), and provides impedance matching.

With present transistors, the gain of a transistor i-f stage at 455 kc is between 20 and 30 db.

Transistors are not unilateral devices. Internal feedback, analogous to the grid-plate admittance of vacuum tubes, may lead to instability in high-frequency amplifiers if both input and output are tuned. Oscillations can be prevented by neutralizing arrangements.

Radio-Frequency Amplifier. The design considerations relating to i-f amplifiers also apply to r-f amplifiers: impedance matching antenna input and interstage coupling circuits with good power transfer properties are desired.

Transistor characteristics are not uniform throughout the entire r-f range. In a grounded-emitter configuration, both input and output impedances decrease with increasing frequency. Consequently, the design of the r-f stage is somewhat more complicated than that of the i-f amplifier.

Capacitive- or inductive-type tuning can be used. The latter is superior in that the r-f bandwidth remains more nearly constant throughout the r-f frequency range, whereas with capacitive tuning this bandwidth varies approximately as the square of the frequency in case of parallel tuning. The inductive tuner also lends itself more readily to miniaturization. Typical transistor impedance levels and the usually desired r-f selectivity lead to inductances varying between, say, 3 and 30 μh. Special ferrite slugs can be used.

With ferrite loop antennas, capacitive tuners must be used. This requires considerable additional space, especially if the receiver is equipped with a tuned r-f stage.

Using modern transistors, a reasonably uniform gain of 20 db can be obtained throughout the r-f range.

Local Oscillator. The local oscillator must satisfy the following requirements:

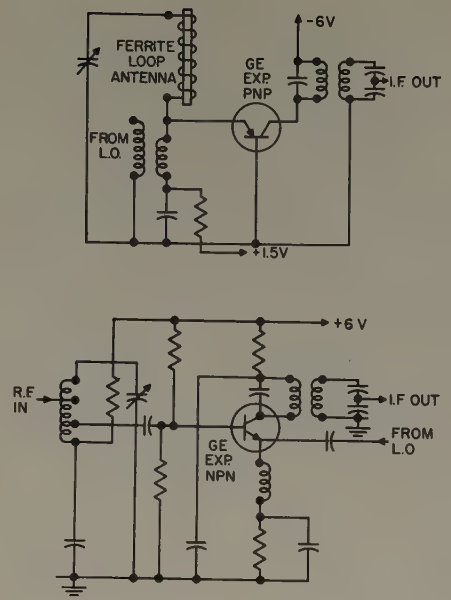
1. It must oscillate in a reasonably uniform manner in the frequency range from 1 to 2 mc. (An intermediate frequency of 455 kc is assumed.)

2. Adequate power output is required for efficient converter operation. The oscillator feeds a transistor converter, the input impedance to which might be quite low.

3. The frequency of oscillation must be essentially independent of temperature and supply voltage variations. (The power supply is usually a battery, the voltage of which may decrease in some cases by as much as 40 per cent of its original value during its useful life.)

The requirements can be met using either point-contact or junction transistors. See Fig. 2.

The advantage of using point-contact transistors resides in their inherent negative resistance characteristic. Nega-



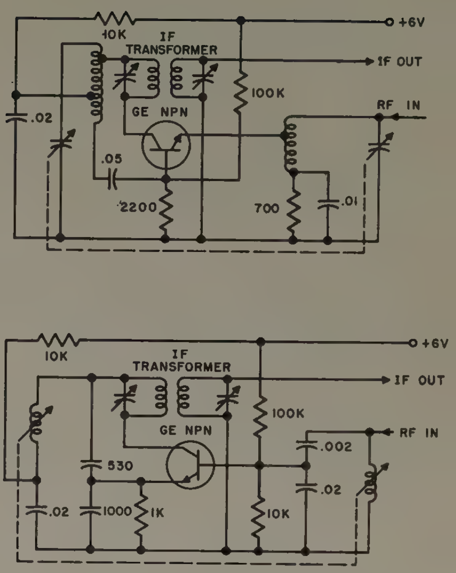


Fig. 3 (left). Converters: r-f and l-o inputs fed to same electrode (above); r-f and l-o inputs fed to different electrodes (below). Fig. 4 (right). Single junction-transistor oscillator-converters

tive resistance oscillator circuits are extremely simple with only a few components and no feedback loop.

Junction transistors are superior, however, in that smaller supply voltage can be used (approximately 1 volt instead of 10 or more for point-contact transistors) to obtain frequency-stable operation and adequate output power. Feedback from collector to base will often result in more satisfactory operation than feedback to emitter. Frequency stability is achieved by properly biasing the transistor and connecting it across only a portion of the resonant circuit so that the oscillation frequency is essentially independent of variations of transistor impedances.

The application of point-contact transistors was considered only in the oscillator. Amplifying stages should use junction transistors, the gain and stability of which will generally be superior.

Converter. Various circuit arrangements will give reasonably uniform conversion gain in the considered frequency range. The conversion gain is a function of the operating point and of the amplitude of the injected oscillator voltage. Good conversion gain is obtained, of course, when operating in the most nonlinear portion of the transistor input characteristic: low d-c emitter-current values of the order of a fraction of a 1 ma are required. The gain has a maximum in the neighborhood of 100 microamperes. The gain versus injected oscillator voltage characteristic also shows a maximum which, in the case of emitter injection of the oscillator voltage lies near 1 volt. Reasonably uniform conversion gains of 15 db can be easily achieved.

The r-f signal and the oscillator voltage can be fed to the emitter or the base. It is often easier to achieve stable operation in the grounded-base configuration (both r-f and oscillator injection into the emitter). Two typical converter circuits are shown in Fig. 3. The coupling networks preceding and following the converter are designed in accordance with principles generally applicable to tuned transistor amplifiers. Input and output impedances of the converter, however, will generally be considerably higher than those of r-f and i-f amplifiers due to low d-c operation.

Combined oscillator-converter circuits using only one transistor for the performance of both functions have been designed. Two typical arrangements with capacitive, and inductive tuning respectively, are shown in Fig. 4.

In both circuits, the i-f voltage is developed across the transformer in the collector circuit. In one case, from the r-f point of view, the transistor is connected in the grounded-base configuration, in the other, the grounded-emitter arrangement is used. In the former case, the oscillator feedback is from collector to emitter; in the latter, from collector to base.

It has been mentioned previously that for maximum conversion gain there exist optimum values of d-c emitter current and of applied oscillator voltage. Consequently, the operating point of a transistor operating simultaneously as oscillator and converter must be chosen carefully. If the operating point is shifted from its optimum value either by increasing or by decreasing the d-c emitter current, the gain will be reduced. This feature is valuable and can be used as the basis for different methods of automatic gain control.

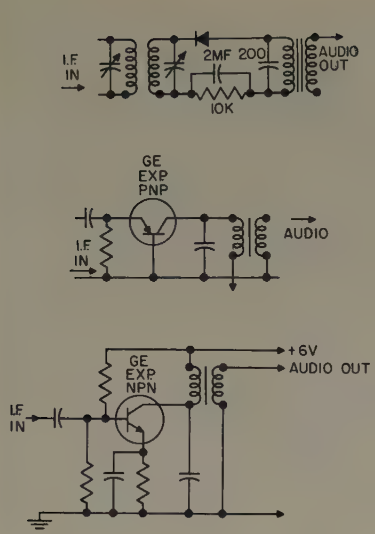
Second Detector. Detection can be performed with either diodes or transistors. If diodes are used, it is necessary to obtain the output of the i-f amplifier at a relatively high-voltage level for linear detection. The detected signal is fed into a low impedance (the following audio stage) and audio-frequency matching is necessary in order to obtain reasonable efficiency. Fig. 5 shows such an arrangement.

Transistor detection is usually superior to diode detection for several reasons:

1. At small signal levels, both diodes and transistors will lead to square-law detection. However, using transistors essentially linear detection can be obtained at somewhat smaller power levels than with diodes.

2. The transistor detector has considerable power gain and acts as the first audio stage. This is particularly pronounced in the case of the grounded-emitter configuration. (Typical gain: 20 db referred to modulation power.)

3. Automatic gain control of transistor amplifiers requires control power. The d-c power obtainable from diode detectors is usually insufficient and, therefore, a d-c amplifier (or an additional i-f amplifier) would have to



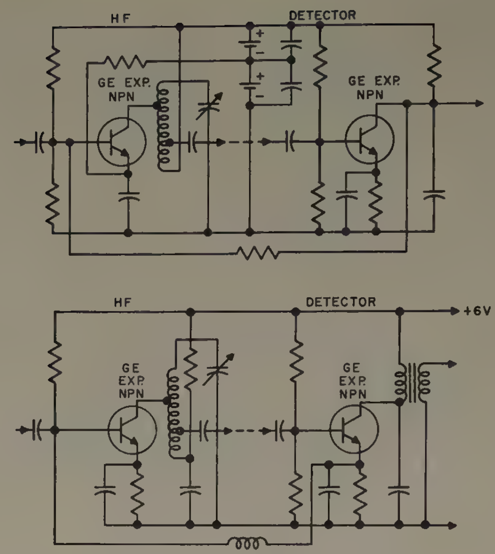


Fig. 5. Detection: Diode detection (upper left); grounded-base transistor (center left); grounded-emitter transistor detection (lower left). Fig. 6 (right). Automatic gain control: By emitter current control (above right); by collector voltage control (below right)

be included in the feedback path for satisfactory operation. The d-c power gain of transistor detectors eliminates this complication, the detector acting as a d-c amplifier and delivering sufficient control power for automatic gain control. The grounded-emitter configuration will usually give superior results.

Typical input impedances of transistor detectors are: 20,000 ohms for grounded-emitter, 3,000 ohms for grounded-base configurations. Examples of detector circuits using transistors are drawn in Fig. 5.

Automatic Gain Control. The gain of transistor amplifiers decreases with either decreasing emitter current or decreasing collector voltage. Consequently, at least two types of automatic-gain-control circuits can be designed.

Both principles require control power. This d-c power is preferably obtained from a transistor detector and can be boosted by operating the controlled a-c stage simultaneously as a d-c amplifier.

If emitter-current control is used, the control voltage is applied to the base of the controlled stage. Resulting changes of d-c base current are amplified and appear as large changes of emitter current and gain.

If collector voltage control is used, the control voltage is also applied to the base. Variations of base current appear as amplified variations of collector current. The resulting change in voltage across a resistor inserted into the collector circuit leads to changes of collector voltage and gain. Fig. 6 illustrates both automatic-gain-control principles.

Audio Amplifier. Transistor audio amplifiers are well known and only a few remarks concerning these circuits should be made here. The grounded-emitter configuration without interstage matching due to transformer cost, will be preferred in preamplifier and driver stages.

The output stage may be single-ended or Class *B* push-pull. The push-pull stage may consist of two identical *p-n-p* or *n-p-n* transistors and associated transformers or a *p-n-p–n-p-n* combination can be used, in which case no input transformer is needed. If the supply voltage is low, such a combination in grounded-collector configuration will directly drive a speaker with somewhat high but readily attainable value of voice coil impedance, 25 to 100 ohms.

The output power of commercially available transistors is limited. The basic limitation is due to maximum admissible collector dissipation, but with present transistors operating at low supply voltages, the undistorted output power is limited mainly by the reduction of α at higher currents.

The efficiency of the Class *A* output stage will be close to 50 per cent at maximum rated output, of the order of 100 milliwatts. However, the average efficiency will be considerably lower.

The Class *B* push-pull stage leads to higher efficiencies, theoretically, up to 78 per cent with small stand-by power; but this efficiency will be hard to realize if the supply voltage is small and the currents accordingly high. The power dissipated in the emitter circuit may be quite large. Output powers of several watts have been obtained with experimental power transistors. Ordinary units in push-pull will yield up to 500 milliwatts.

TRANSISTOR RECEIVERS

The complete diagram of an early transistor receiver i shown in Fig. 7. It contained eight early Genera Electric *p-n-p* junction and one General Electric point contact transistors. The ferrite loop antenna feeds th converter (gain 4 db) which is followed by a 3-stage i- amplifier. The gain per i-f stage was approximately 12 db A transistor detector was used in grounded-base configura tion feeding a 3-stage audio amplifier. The maximum out put of the single-ended stage was 25 milliwatts. Th sensitivity was approximately 800 microvolts per mete (relating to 5-milliwatt output). Selectivity and imag rejection were inadequate, and no automatic gain contro was applied. The power supply consisted of a 30-vol collector and two 1.5-volt emitter batteries. The batter lifetime was 25 hours.

This rudimentary set can be contrasted with a more up to-date receiver, see Fig. 8. This set also uses a ferrit loop antenna, feeding an r-f amplifier stage with an averag gain of 16 db. The local oscillator is a junction transisto and feeds the converter the gain of which is approximatel 15 db. The 2-stage i-f amplifier has a gain of 45 db. Th grounded-emitter transistor detector delivers automatic gain-control power to the first i-f stage. Collector voltag automatic gain-control is used in this unit. The audi amplifier consists of a driver and a Class *B* push-pu

p-n-p–n-p-n combination output stage operating directly into a 50-ohm speaker. The supply consists of eight 1.5-volt "penlight" batteries: 2 × 6 volts because of the complementary output arrangement. (A power supply consisting of only four 1.5-volt penlight cells was used in another version of the same receiver using two *p-n-p* transistors and transformers in the output stage.) The battery lifetime is approximately 100 hours. Selectivity, noise performance, and image rejection of the set are superior to most portable sets obtainable on the market. The maximum output power was 200 milliwatts and the 50-milliwatt sensitivity approximately 100 microvolts per meter (the 5-milliwatt sensitivity was approximately 35 microvolts per meter).

Temperature stability has been provided for by proper bias arrangements and circuit design. The set operated satisfactorily (with reduced sensitivity and peak power output) when the supply voltage was reduced to 3 volts.

Another version of this receiver used a single transistor oscillator-converter and performed equally well.

GENERAL CHARACTERISTICS

A FEW remarks must be made concerning the over-all performance and basic design factors of transistor receivers.

Sensitivity. Adequate sensitivity depends on the realization of two factors: low noise and sufficient over-all gain.

The noise figure of transistors is fairly good (6 db or less) at radio frequencies: consequently, sensitivities of the order of a few microvolts per meter can be easily realized. Noise is also generated in the converter, but can be taken care of by an r-f stage with high gain.

The gain of high-frequency amplifiers (i-f and r-f amplifiers, converters) using tubes is 30 to 45 db. Present transistor amplifiers yield only 15 to 30 db. Consequently, for equal performance, more transistors than tubes are needed.

It has been pointed out that transistor detection can be performed with less i-f power than diode detection. This leads to an important conclusion from the system point of view: a comparatively larger part of the over-all gain can be placed in the audio amplifier than in tube receivers. Reduction of i-f gain and increasing of audio gain also reduces the number of transistors required because the gain of a single stage at audio frequencies is higher than at i-f or r-f frequencies.

Selectivity. In order to achieve good selectivity, the "unloaded" Q of the tuned circuits must be very high. Loading down these tuned circuits with output and input impedances of transistors results in desirable bandwidths corresponding to moderate "operating" Q's. This consideration applied to i-f and r-f circuits alike and, of course, to the loop antenna.

The over-all selectivity curve might not be quite symmetrical due to the reflected impedances of transistor amplifiers. The resulting small vestigial side-band effect is not too important.

Distortion and Frequency Response. Transistors are basically more linear devices than vacuum tubes. The distortion in Class *A* amplifiers, if correctly operated, will be very small. It is, however, quite difficult to obtain low-distortion performance with Class *B* push-pull amplifiers without considerable loss of gain.

Distortion may also be caused by automatic-gain-control circuitry if not carefully designed.

The audio-frequency response of transistor receivers is

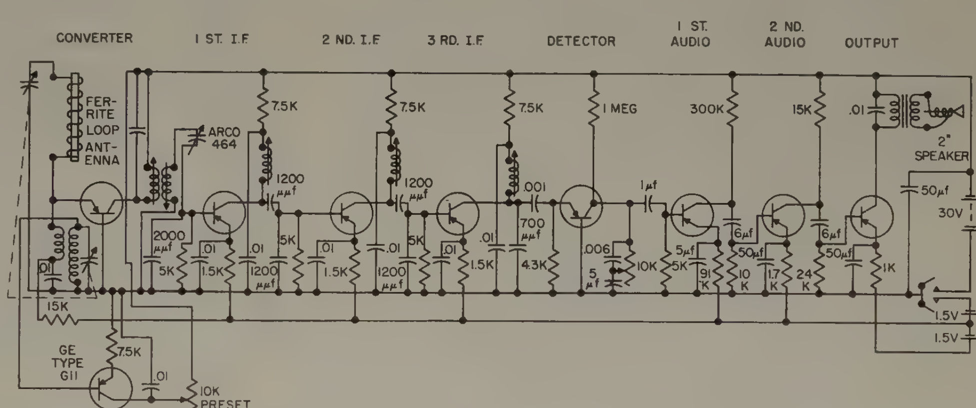


Fig. 7. Early model transistor receiver. Note: All transistors are General Electric experimental *p-n-p* except local oscillator

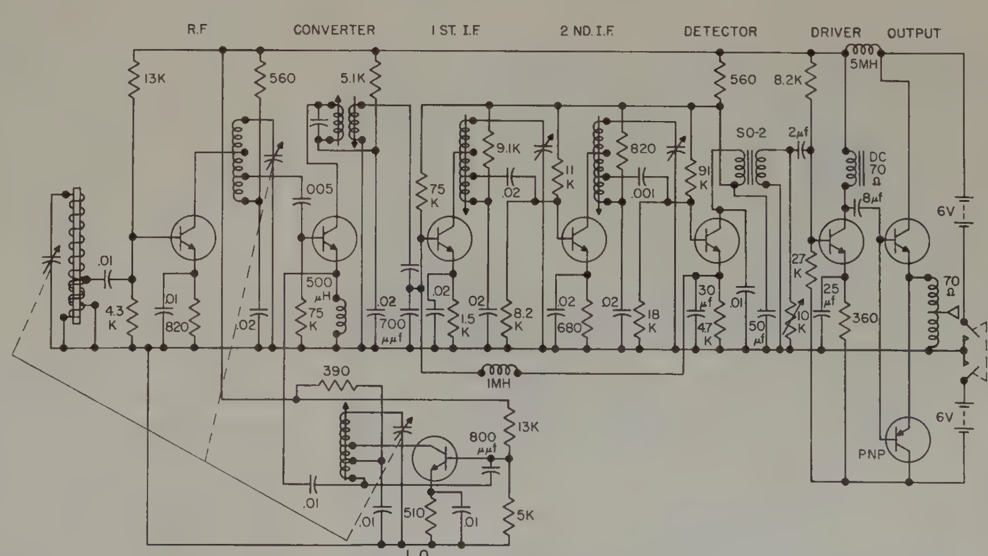


Fig. 8. More recent model transistor receiver. Note: All transistors General Electric experimental *n-p-n* except one output transistor which is General Electric experimental *p-n-p*

no great problem. For good low-frequency response, large-capacity low-voltage condensers are used for coupling and by-passing.

Power Supply. The choice of the proper power supply is one of the major design problems of transistor receivers. The tendency is to avoid special batteries and to use a number of ordinary flashlight batteries obtainable in any drug store. This will lead to reduction of operating costs.

Most functions in the receiver require comparatively low supply voltage. Three volts is adequate for all stages except possibly the driver and output amplifiers. If considerable power output is required, low voltages mean large currents and with present transistors this might lead to distortion (due to the aforementioned decrease of α with increasing currents). Furthermore, the d-c emitter voltage of the output stage may be an appreciable fraction of the total available voltage. (This implies strongly reduced efficiency and large stand-by power even in case of Class *B* push-pull output stages.) On the other hand, low-voltage large-current operation means that direct drive of a low impedance speaker is possible, and this feature is very desirable.

At the present time, it seems that 6 volts (= four 1.5-volt batteries) are needed due to output stage requirements. If an input transformer is to be avoided (*p-n-p–n-p-n* combination), 12 volts (eight cells) seem to be reasonable.

The current drain of all but the driver and output stages are small. Typical values are:

R-f Amplifier:	1 milliampere
Oscillator:	0.5 milliampere
Con.erter:	0.2 milliampere
I-f Amplifier:	1 milliampere
Detector:	0.1 milliampere

The driver and output stage drains are limited by the maximum efficiencies of Class *A* and Class *B* push-pu stages. The lower the supply voltage, the larger will b the relative stand-by power of the output stage.

With careful design, operating costs of 0.1 to 0.5 cent pe hour can be obtained. This compares favorably with to 10 cents per hour in tube receivers.

Components. Throughout the preceding sections, th use of experimental General Electric transistors wa assumed. The uniformity of transistors has considerabl improved during the past years and with exception of th push-pull output stage, it was possible in a given set to re place transistors by other transistors of the same type with out further circuit adjustment.

It was mentioned above that the gain of transistor high frequency stages is inferior to that of tubes. This situatio will, however, certainly improve in the not too distan future.

One of the advantages of transistor receivers is miniatur ization. Unfortunately, the desirable miniaturized com ponents are not readily available for all desired purposes Extremely small electrolytic capacitors and some audi transformers can be bought, although their present pric is prohibitive. The future calls for commercial develop ment of miniaturized high-frequency coils, transformers, an capacitors. Direct operation into speakers is possible, bu need will arise for the development of efficient moderatel priced speakers with voice coil impedances of 100 ohm or more.

CONCLUSION

PORTABLE TRANSISTOR RECEIVERS of good quality can b built with present experimental transistors. It is ex pected that such receivers will appear on the market a soon as transistors and other miniaturized components ar produced at a reasonable price.

Joint Army-RCA Demonstration of Tactical Television

Army officers, industrial leaders, and members of th nation's press witnessed for the first time recently th Army's "command post of the future," equipped with tele vision "eyes" that enable the combat commander to see an influence the course of battle.

High-ranking United States Army participants wer headed by the Army's Chief of Staff, General Matthew B Ridgway. Major General George W. Smythe, Deput Commander of the Second Army, in whose area the demon stration was held; Major General George I. Back, Chie Signal Officer; and Brigadier General David Sarnof Chairman of the Board of the Radio Corporation o America, also had principal parts in the demonstration.

In the command post set up for the event, images from tactical television cameras on the ground and in the air gav the commander and the audience an instantaneous view o widely separated actions along the simulated front, show ing the movement of troops.

Aircraft Tachometer Indicator Starting

L. T. AKELEY
MEMBER AIEE

STARTING performance of aircraft tachometer indicators has received considerable attention with the advent of the gas-turbine engine. Military specifications are requesting lower starting indication of the tachometer indicator to better aid the aircraft pilot to start his engines properly and safely.

Fig. 1 shows schematically the elements of a widely used aircraft tachometer system. In this system a 3-phase generator is mechanically coupled to the aircraft engine shaft. Three-phase power from the generator is carried electrically to the instrument panel where the indicator's synchronous 3-phase motor is excited. A dragmagnet attached to the rotor shaft produces a torque proportional to speed of rotation on a lightweight eddy-current disk. The disk—gear-train—pointer system is restrained by a spiral spring which exerts a torque counter to the disk torque such that the pointer position indicates disk torque, and thus rpm.

Fig. 2 shows schematically the rotor construction used in the tachometer indicator motor. The rotor has two torque-producing elements: a permanent magnet J_m, and a hysteresis element J_h. J_m provides starting and lock-in torque, whereas J_h provides higher frequency torque for accelerating the rotor close enough to synchronism for the permanent-magnet rotor to "pull-in." J_d is the dragmagnet and shaft. Since J_d is to be driven synchronously by J_m and J_h, the three elements must be mechanically attached to each other or the common shaft. First, suppose that all are attached solidly to the shaft. Such a rotor would not start well as all three inertia elements must be accelerated at the same time. Second, a better construction, attaches J_h and J_d solidly to the shaft and permits J_m less than 360° freedom on the shaft. This construction has been used in tachometer indicators for a long time. Third, a still better construction is found in a current design, which has both J_m and J_h free on the shaft such that the rotor starts as follows: J_m, which derives its torque from the reaction of its own field with the stator ampere-turns, accelerates to synchronism before it is coupled mechanically to J_h by means of interfering pins on the two elements; J_h is then accelerated to synchronism before it is coupled to the shaft and to J_d, which is solidly attached to the shaft; J_d is then accelerated to synchronism. The above actions will occur in series in the course of normal starting.

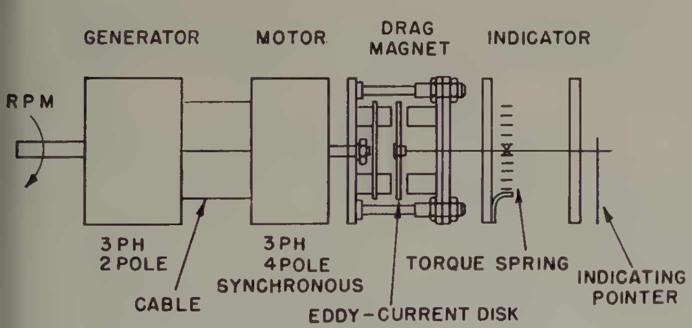


Fig. 1. Schematic of aircraft tachometer system

Equations have been developed in the article for calculating the starting frequency of a motor in terms of locking torque of the rotor, inertia of the rotor elements, friction torque of the bearings, mechanical unbalance torque of the rotor elements, and other motor parameters. Starting-frequency calculations are made for the three rotor constructions. From these calculations one may conclude that the third construction, with both the rotor magnet and hysteresis element free on the shaft, is best for low-frequency starting.

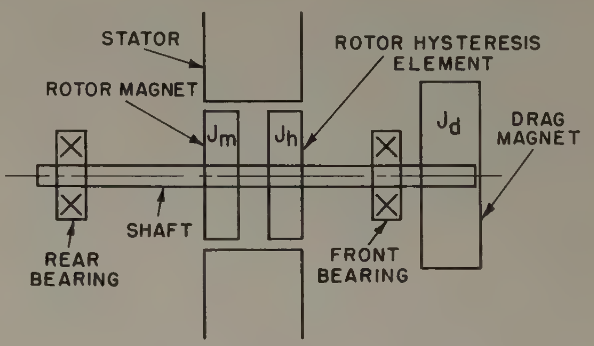


Fig. 2. Schematic of tachometer indicator motor

Samples have been built and tested with all three constructions. Tests and observation of the performance of these samples verify that the third construction is superior to the second, and the second, superior to the first. Observations confirm, for example, that the starting actions of the third construction occur in series as stated in the foregoing. Unbalance and friction torques of the dragmagnet, however, may be such that the rotor magnet will be pulled out of synchronism, reverse its direction, start again, and possibly repeat the starting sequence several times before getting the dragmagnet up to synchronous speed. Starting tests on 581 production indicators having the third construction show a median starting frequency (with minimum generator excitation) of 1.75-per-cent rated speed, or 74 rpm. Test results show good agreement with calculated starting frequencies.

Digest of a paper 54-358, "Aircraft Tachometer Indicator—An Analysis of Design Factors Affecting Starting Performance," recommended by AIEE Committee on Air Transportation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publications in AIEE *Applications and Industry*, 1954.

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Magnetic Characteristics of Cores in Amplifiers

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A METHOD of measuring the magnetic characteristics which control the manner in which cores operate in self-saturating magnetic amplifiers is necessary both for economical production and accurate design of such amplifiers. Because of the eddy-current-type effects present, even in thin gauges of the rectangular loop magnetic materials used in cores for high-performance self-saturating magnetic amplifiers, it has not been found possible to directly relate the amplifier performance to usual d-c or a-c hysteresis loop measurements.[1,2] When operating in an amplifier, a core will generally follow a peculiar minor hysteresis loop determined by the combination of core magnetic characteristics and conditions imposed by amplifier circuitry.[2] Thus to predetermine the behavior of a core, it must be tested under conditions which simulate amplifier operation.

A test method, shown in Fig. 1, has been developed[3] for measuring the pertinent characteristics of a core under conditions that approximate those in a self-saturating amplifier. Only a few turns are required and the placement of these turns on the core is not critical. Thus, the method is easily adaptable to the high-speed production testing of toroidal magnetic amplifier cores. The principle of the test is to apply a constant control demagnetizing force to a core for a period of 1/2 cycle of the test frequency in order to reset the flux from the positive saturation level in a manner similar to operation in a magnetic amplifier. The flux is then driven back to positive saturation during alternate half cycles by a pulse of exciting current and the total flux change per cycle is measured in terms of the alternating voltage induced in a pickup winding.

The practical value of this test method is best indicated by the encouraging results obtained from its use in the production testing and matching of toroidal cores for a wid variety of critical high-performance magnetic amplifiers

It has been found possible, on an empirical basis, t specify a range and match of core test characteristi values required for satisfactory operation of any particula amplifier design. For example, the introduction of thi procedure for core selection and matching in a pilot plan scale production of a wide variety of 2- and 4-core critica amplifier designs raised the over-all yield at first operationa test from about 70 per cent to 90 per cent. The previou core test method was based on measurements of pea differential permeability and coercive force for a major a- hysteresis loop obtained with sinusoidal magnetizing force

Theoretical investigations of the relation between cor tester measurements and amplifier performance hav yielded a new approach to magnetic amplifier circuit analy sis. By this approach it is possible to directly relate a amplifier control characteristic curve to the amplifier de sign, core size, and core material magnetic characteristic as measured by the core tester. This analysis is complete accurate only for the limited range of applications fo which the core operates in a manner similar to core teste operation. In particular, the analysis is dependent on tw requirements in regard to amplifier operation. These ar that the amount of flux reset obtained with a given averag value of control demagnetizing force will be the same unde amplifier and core test conditions; and that the volt seconds appearing in the gate winding, associated with th increase of flux from the reset point to positive saturation be effective in reducing the output voltage while the volt seconds associated with the reset of flux will not direct appear in the amplifier output. However, even for ampli fier designs in which thes requirements are not met, th method is valuable for ap proximate design calculation

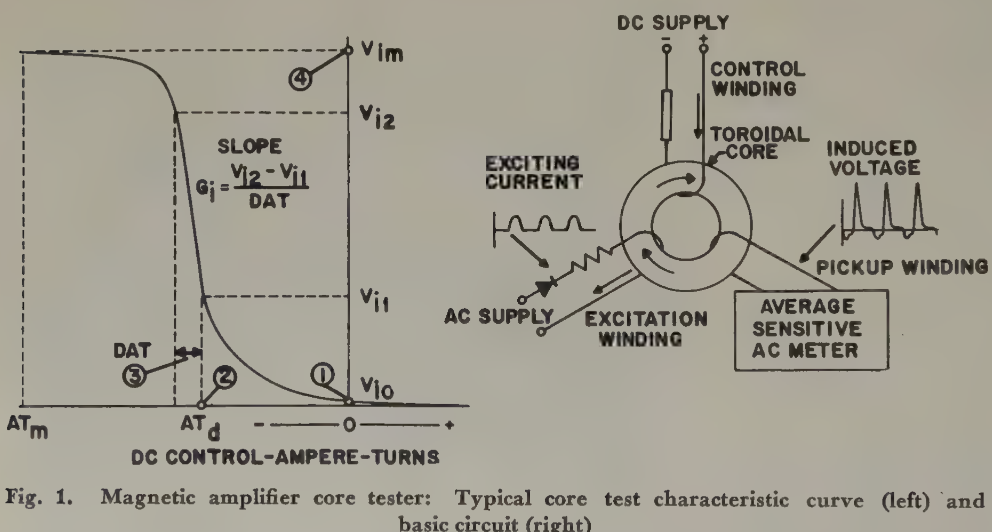

Fig. 1. Magnetic amplifier core tester: Typical core test characteristic curve (left) and basic circuit (right)

Standard measurement points—1. V_{i0}, measured at zero control ampere-turns; 2. Control ampere-turns measured at specified voltage V_{i1}; 3. Gain on linear region between specified voltages V_{i2} and V_{i1}, as calculated from measured DAT; 4. V_{im}, measured at specified control ampere-turns AT_m

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A Survey of Magnetic Recording

S. J. BEGUN

Great advances have been made in magnetic recording in a short period of time. At present, it is being used in the fields of computers, instrumentation, business machines, and control mechanisms. An interesting presentation is given of its development and applications.

THE understanding of magnetic recording and playback processes, and the applications for magnetic recording have made considerable strides during the last 15 years. In the early 30's, magnetic recorders had to operate with a recording-medium speed from 5 to 10 feet per second to secure a frequency response from 50 to 5,000 cycles per second. Today, it is almost standard practice to achieve the same response characteristic with much higher signal-to-noise ratio and with considerably less distortion even though the medium moves only with a velocity of 2.5 to 3 inches per second. This represents a speed reduction of 20 to 1. The weight reduction is still greater, namely, 50 to 1 since the specific weight of plastic tape is at least 2.5 times less than that of steel tape, as was used then. No other method of recording, whether mechanical or optical, has made such an advance in such a short period.

A brief review of the history of magnetic recording indicates that 20 years ago the available magnetic-recording media with their relatively low coercive force limited the high-frequency response. In about 1936 Vicalloy tape, with more suitable magnetic properties, shifted the burden of improvements to magnetic heads. Then, coated magnetic tape and ring heads made their appearance—both intrinsically capable of a performance characteristic which has as yet not been fully exploited.

RECORDING MEDIA

OF all the various magnetic-recording media which have been employed in the past, only the ones using magnetic particles imbedded in plastic materials have achieved a position of prominence. Wire and tape, whether made from a solid magnetic alloy or by plating a magnetic alloy on a nonmagnetic core, are now used only for special purposes. There are good reasons for preferring a recording medium with a thin layer of dispersed magnetic particles. Such layers can be easily applied to a wide plastic or paper base which can be cut into tapes of any desired width. These tapes have great mechanical flexibility, are relatively light, and can be conveniently handled by the user. Furthermore, they possess magnetic properties much superior to those of solid or plated tapes.

The iron-oxide particles which constitute the magnetizable substance of the layer have an average particle size of approximately 0.4 micron. Particles rarely exceed 0.7 micron and are mostly needle-shaped with a length-to-thickness ratio of about 4 to 1.

The bulk magnetic properties of these layers can be changed over a considerable range of coercivity. The most widely used tapes have a coercivity from 200 to 300 oersteds, and a remanent induction of about 600 to 800 gauss. Higher coercivity does not add materially to the medium's capability of retaining short wavelength signals if at the same time the remanent induction cannot be substantially increased too. Unfortunately, it is not easy to raise the remanent induction much since the coating becomes brittle when the percentage content of magnetic particles is too large. Present-day coatings contain, by weight, 75 to 85 per cent, and in volume, 45 to 55 per cent, magnetic particles. The relatively low remanent induction values are dictated by two factors, namely, the demagnetization of the material because of the nonmagnetic gaps between particles, and the reduced effective cross section since only half of the layer is occupied by particles. It would indeed be desirable to have a magnetic-recording medium with higher remanent induction, and then also with higher coercivity because the energy content of the reproduced signal would correspondingly increase. Much work is done these days to obtain an increase of remanent induction by more suitable shaping of particles so that they can be arranged in a pattern which will minimize the demagnetization effect. It is well to recognize, however, that for sound-recording applications, magnetic media have been perfected to a point where there is now little pressure for further improvements.

This statement does not apply when magnetic-recording systems are employed for instrumentation work. So-called dropout of signals which can be traced to nonmagnetic impurities and pinholes in the coating adversely affect the use of magnetic tapes for computers and telemetry. Surface roughness, nonuniform particle distribution, and variation of coating thickness, all causing undesirable level variations, make it practically impossible to retain data with the required accuracy when the conventional intensity method commonly used for sound recording is employed. It is, therefore, general practice to resort to some coding method such as a frequency modulation, pulse-width-ratio modulation, or other similar schemes. Incidentally, d-c values and low-frequency phenomena can also be recorded and reproduced when carrier techniques are applied. Unfortunately, the use of many such tricks introduces new problems which are caused by speed variations of the recording medium.

A special article recommended for publication by AIEE Committee on Television and Aural Broadcasting Systems.

S. J. Begun is director of advanced development, Clevite-Brush Development Company, Cleveland, Ohio.

This will be discussed in somewhat greater detail in a later part of this presentation.

It should be mentioned here that the recent introduction of DuPont Mylar polyester film as a support for a magnetic coating has greatly reduced speed variations due to its higher elastic modulus than that of acetate film which, so far, has served almost exclusively as base material for magnetic tapes. In addition, Mylar polyester film maintains

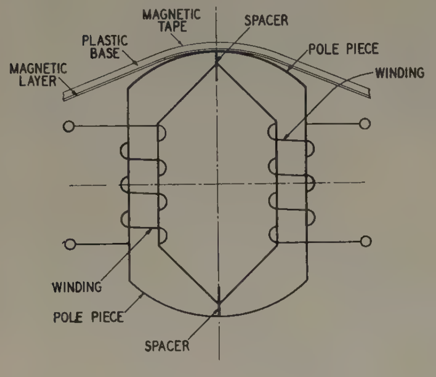

Fig. 1. Basic structure of a magnetic ring head

great physical stability over a temperature range from −60 to +95 C. Measurements reported, but not yet published, by members of the Reeves Soundcraft Corporation indicate that a 48 to 72 hours' exposure to 150 C causes only a 3-per-cent permanent shrinkage, and a 72 hours' exposure to 125 C produces less than 1-per-cent shrinkage. Since the moisture absorption of Mylar is 1/30 that of cellulose acetate, all practical problems of shrinkage and swell disappear.

Recent improvements have also been made in reducing the coefficient of friction of the magnetic layer by surface polishing and by adding lubricants to the coating. This is important in counteracting flutter effects which are caused by friction-excited vibrations.

The question is frequently raised as to what extent presently available recording media might control the shortest wavelength which can still be recorded and reproduced. Since in a rough approximation each half wavelength can be assumed to equal the length of a dipole magnet, and since each particle might be considered the shortest possible magnetic dipole, particle sizes of half a micron will permit recording wavelengths as short as 1 micron. This is equivalent to recording 25,000 cycles per lineal inch along the motion of the recording medium. If frequencies up to 4 megacycles have to be retained, as might be needed for storing the information content of a television program, the minimum velocity of the recording medium is approximately $13^1/_2$ feet per second.

It has been reported by members of the Radio Corporation of America that video recordings have been made with a tape speed of 30 feet per second, but more than one magnetic track has been employed. No specific information has been given regarding the highest frequency which this system was capable of recording and reproducing on any one of the four video channels.[1,2] Present-day commercial magnetic-recording systems can resolve wavelengths of about 0.0004 inch.

MAGNETIC HEADS

At this stage of the art the magnetic reproducing head sets the limits. The effective gap length of the head must be smaller than the wavelength which the reproducing device is expected to read. To build a practical head with a gap length of less than 1 micron is a difficult if not impossible task. The degree of required mechanical accuracy is far beyond what can be reliably and consistently obtained. The making of heads with an extremely small gap length is further aggravated by the fact that many materials which might magnetically be suitable for pole pieces have a rather coarse grain structure. This is particularly true for the ferrites which are otherwise attractive because of their low eddy-current losses.

When it comes to recording and reproducing frequencies in the megacycle range, eddy-current losses are serious. Magnetic heads made by stacking up laminations of permalloy or other high-mu materials are not too practical in this frequency region. It is also necessary that the separation between magnetic layer of the recording medium and the gap be of a smaller dimension than the length of gap.

During the last 10 years the so-called magnetic ring head has been the basis of all major head design efforts. In a magnetic ring head the magnetic material forms an essentially closed structure with one or more nonmagnetic gaps. The magnetic-recording medium bridges one of these gaps. A schematic sketch of a balanced ring head is shown in Fig. 1. It comprises two pole pieces of equal dimension, each equipped with one winding. The effective gap length which determines the resolution power in reproduction is determined by three factors: 1. the thickness of the spacer separating the pole pieces, 2. the sharpness of the pole-tip corners at the point of contact with the recording medium, and 3. the distance between the pole-piece surface and the recording medium. In Fig. 2 the unequalized response versus frequency of a commercially available head (Brush *BK-1090*) is illustrated. To obtain consistently such a response curve, most careful workmanship and elaborate tooling is required. The pole faces are made flat and the corners sharp prior to inserting a close-tolerance nonmagnetic shim. The contact areas of the pole pieces are polished to improve contact conditions between the magnetic layer of the recording medium and the head. The effective gap length of this head is 3×10^{-4} inches and is determined by inspecting the response of the head versus wavelength and by locating the first point of minimum output in the short-wavelength range.[3]

The playback heads are responsive only to rate of flux changes. This means that the voltage output is proportional to the frequency. In practice, this holds true only for a limited range. The reproduction of very short wavelengths brings in the gap-length effect. The reproduction of wavelengths much longer than the contact length between pole pieces and recording medium in the direction of tape motion causes a part of the recorded flux not to enter the head. Under this condition, an 18-db-per-octave rule applies.

Magnetic heads have been built which are responsive to the amplitude of flux. One type employs the beam deflection of a cathode-ray type tube which is located between

two pole pieces forming a narrow gap where they touch the medium.[4,5] Magnetic-amplifier principles are used in another approach. This is accomplished by changing the permeability of the magnetic structure of the head by means of a suitably excited high-frequency magnetizing field which does not affect the recorded signal.[6] Both these heads can read flux emanating from a stationary medium but are subject to the same limitation with regard to long and short wavelengths as outlined before. A d-c signal longitudinally recorded cannot be detected by any head, since no flux leaves the surface of the medium when the internal flux density remains constant along the length of the recording track.

RECORDING AND REPRODUCTION OF WIDE-BAND FREQUENCY PHENOMENA

Attention might now be turned to the many applications for magnetic recording. One can broadly differentiate between two major usages, namely, recording and reproduction of wide-band frequency phenomena as they occur in acoustical and other related work, and the recording and reproduction of pulses. For sound recording, only a limited degree of long-time stability is needed. It generally suffices if the relative amplitude of the various frequency components is maintained, if the noise is kept small in relation to that of low-level signals, and if distortions do not exceed a predetermined value. Magnetic recording will meet these requirements well. While there is a tendency for short-wavelength signals to exhibit with time and with the number of playbacks level reductions relative to long-wavelength signals, these changes of one or possibly 2 db are generally not objectionable. A signal-to-noise ratio of better than 60 db is unique in comparison with other methods of recording. Harmonic distortions even at this excellent signal-to-noise ratio do not exceed 2 to 3 per cent in commercially available equipment. Signal transfer from one to an adjacent layer of tape, when wound on a reel, might be considered a deficiency. However, the level of the transferred signal is 49 to 57 db down for many commercial tapes.[7] The magnitude of the printed signal depends upon the period of contact between layers, upon the magnetic properties of the magnetic layer and its past history, upon the intensity of the signal recorded thereon, upon the prevailing temperatures, upon the external magnetic field conditions, and upon the separation of the magnetic layers of the tape. When motion-picture film base is used as support for the magnetic layer, signal transfer is extremely small. On the other hand, the use of thinner tapes than the conventional acetate ones such as have been proposed for Mylar polyester film might create a serious printing problem. The application of a small erasing field prior to reproduction has been recommended since it will noticeably reduce the printed signal but hardly affect the parent one.[8]

In the reproduction of sound, casual defects such as caused by nonuniformity of the coating or temporary change of contact between recording head and medium are hardly observable. Experience with six magnetic sound tracks and one control track as pioneered by Cinerama has shown the excellent performance capabilities of magnetic recording. Cinerama's and Cinemascope's demonstrations of the acoustic effect of multichannel sound systems might in due course lead to a commercial version for stereophonic reproduction in homes.

In the field of computing devices and in the area of instrumentation, magnetic recording is playing an ever-increasing part. For these applications some method of coding is frequently required to provide the necessary degree of accuracy. In telemetry and in the recording of seismic phenomena, errors must not exceed a few per cent. Since World War II, telemetering engineers have often chosen frequency modulation as an acceptable coding method. When the original signal is extracted from a frequency-modulated carrier, flutter and wow of the recording medium cause the generation of unwanted signals. Carefully designed drive mechanisms with a peak-to-peak speed variation of 0.1 per cent are now available and keep errors within a few per cent, particularly when wide side bands are used. If accuracy of 1 per cent is desired, a constant frequency signal can be recorded in addition to the frequency-modulated carrier to serve as a reference during playback. This reference frequency can either be made to control the speed of the recording medium

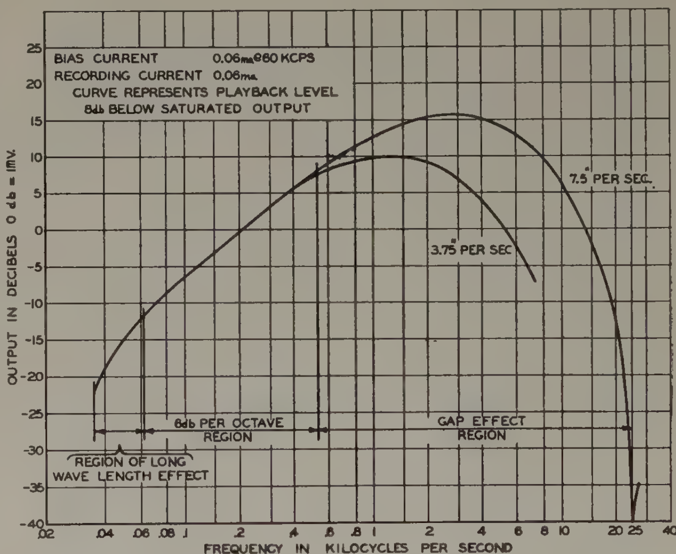

Fig. 2. Output versus frequency for *BK-1090* recorder

during reproduction or to provide some compensation for a purely electronic correction method.[9]

MAGNETIC PULSE RECORDING

Sampling methods are becoming more accepted lately.[10] In this approach the instantaneous amplitude of the signal is determined at precise intervals and the magnitude of each sample is expressed either as the time-duration ratio of the positive and negative pulse length of a square wave or as a digital number. The first type of coding is identified as pulse-width-ratio modulation, and the second as pulse-code modulation. In the pulse-width-ratio modulation usually only one recording channel is used. In pulse-code modulation it becomes frequently practical to record the

binary number corresponding to the amplitude of the signal on parallel channels. Eight channels will reduce the error to less than 1 per cent. In either method it is sufficient to use only three samples for each cycle of the highest frequency component contained in the signal if the sampling is done properly.

Digital computer designers have worked extensively on pulse recording and playback techniques for the last 7 years. They frequently employ tape to store input and output information, and they often use drums as intermediate short-time memory devices. It is obviously desirable to pack as many pulses as possible within a given surface area of the recording medium. In accordance with present-day techniques 200 to 250 pulses per inch can be accommodated in the direction of the motion if the recording medium and head operated in contact, and 80 to 100 pulses if the recording speed is so high that contact cannot be maintained. The pulse density across the width of the medium is much less, particularly if accurate alignment of a number of head gaps is required as is frequently the case. Under those circumstances only 13 to 15 magnetic tracks can be placed within 1 inch of recording-medium width since each pole-piece structure with its associated magnetizing coil dictates a minimum separation of about 0.07 inch. If head-gap alignment is not necessary, 50 tracks per inch might be used. Since pulse-packing density is greater by at least a factor of two when head and medium contact each other, this arrangement is used wherever possible. In most commercial drums, however, the surface speed is so high that it has been the practice to space heads by a distance of 0.001 to 0.002 inch. Over the period of the last year, experiments have been made by the Clevite-Brush Development Company with 1-inch-diameter drums, employing a rubber tire with imbedded magnetic particles as a recording medium, and maintaining physical contact between the tire surface and the magnetic head. Even though the drum rotates at 3,600 rpm and, thus, has a surface speed of more than 180 inches per second, neither the head nor the tire have shown any objectionable wear and deterioration after more than 3 billion revolutions. Rubberlike bands with imbedded magnetic particles were developed by the Bell Telephone Laboratories for applications where long life in continuous use is required. For some years the Clevite-Brush Development Company has made magnetic bands for announcing and control systems, and for delay devices.

For some applications the use of small drums might be quite advantageous not only because more pulses can be accommodated per square inch of surface, but also because the volume-to-surface ratio increases proportionally with the diameter, thus making a bigger drum more wasteful in terms of space requirements. Last, but not least, the mechanical accuracy required for a small drum does not need to be as great as that for one with a 10- to 14-inch diameter which has heads slightly spaced from the periphery.

RECENT APPLICATIONS OF MAGNETIC RECORDING

One of the great advantages in using magnetic tapes to handle input and output data of a computer lies in the fact that a 10-inch reel, loaded with 1/4-inch tape and occupying a space of 16 cubic inches, can retain as many bits of information as can be accommodated in a volume of approximately 3.5 cubic feet filled with typical paper cards now frequently serving as storage media. Furthermore, the random access time to magnetically recorded data is at least 16 times faster than to markings on paper cards, as previously done.

Tape-controlled machine tools are still in the experimental stage. Information representing the work cycle is stored on the recording medium and dictates the machine motion and on-off operations during playback.[11]

It is only recently that magnetic recording has begun to play an important part in the field of geophysical exploration work. Up to now, signals generated by explosive charges and reflected by the various boundary layers of the earth's strata are picked up by a series of geophones and are optically recorded on a suitable photographic paper. In many instances it is desirable, and often essential, to delay slightly one graphic tracing with regard to another, or to eliminate certain frequency components to obtain best results when interpreting a record by visual inspection. The original magnetic record can also be preserved and used at later times when new methods of evaluation should become available.

During World War II various military agencies had found magnetic recording valuable for special applications, but the total sales of all devices built in this period never exceeded a few million dollars. Even as late as 1945 magnetic recording was practically unknown to the public. There are no accurate sales figures available for 1953. Conservative estimates indicate that more than 200 million dollars' worth of magnetic sound-recording equipments and accessories alone were bought by the American public and the interest is still growing. But the real future of magnetic recording lies in the area of instrumentation and in the field of computers, business machines, and control mechanisms.

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Reactor Circuit with Quiescent Current Compensation

R. J. RADUS

MAGNETIC AMPLIFIERS of the saturable reactor type are used in applications which require a substantially linear relationship between d-c input and d-c output.

The basic saturable reactor circuit, as applied for a typical metering scheme, is shown schematically in Fig. 1. The transfer characteristic of this typical application, given in Fig. 2, shows the substantially linear range of operation. It also shows a nonlinear range in the near vicinity of zero control and a finite or quiescent output at zero control. Because of this quiescent output, the field of application is somewhat limited. An interpretation of the transfer characteristic, as concerns the calibration of the instrument M of Fig. 1, shows that the instrument scale is linear for but a limited range and that the mechanical and electrical zeros of the instrument will not be coincident. These deviations from "to-zero" linear operation, while not being critically restrictive for the metering scheme of Fig. 1, are undesirable since they require a special calibration of the instrument scale.

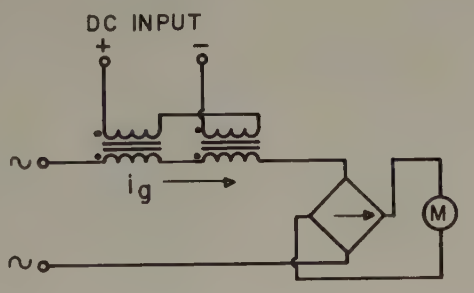


Fig. 1. Basic saturable reactor circuit as applied for d-c metering

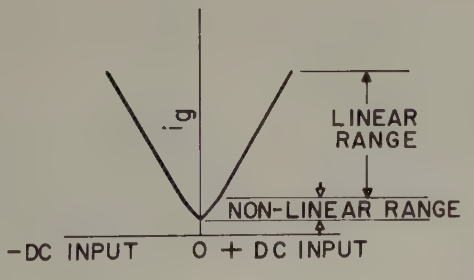
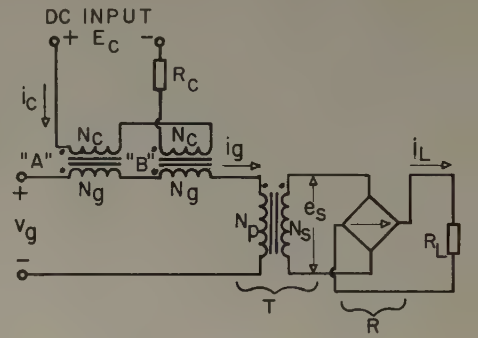


Fig. 2. Transfer characteristic of basic saturable reactor circuit as applied for d-c metering

The operation of the circuit introduced in this digest is concerned with eliminating the quiescent output of a single-ended series-connected saturable reactor which has relatively low control circuit impedance.[1] The new circuit is a modification of this basic circuit and is shown schematically in Fig. 3. The modification is the addition of a transformer T between the reactors and the rectifier R in the circuit.

The elimination of quiescent current is the result of a unique combination of the nonlinear characteristics of the transformer and rectifier. In effect, the transformer acts to shunt the reactor quiescent current from the rectifier, i.e., the transformer absorbs the quiescent current without producing an appreciable secondary voltage. The action required of the rectifier is that it block the quiescent secondary voltage which is actually produced. The rectifier performs this service effectively by presenting a high resistance in the circuit to this relatively small quiescent secondary voltage.

Fig. 3. Single-ended saturable reactor circuit for full-range linear operation



For other than the quiescent condition, the transformer acts essentially as a current transformer and the secondary current is relatively independent of the nonlinearity of the rectifier resistance. The magnetization which is associated with the transformer operation is recognized as a source of error in the relationship between reactor current, i_g, and output current, i_L; however, it need not have a restricting effect on the full-range circuit operation.

Experimental testing has been conducted on a model which is capable of delivering a nominal output of 3.5 milliamperes into a 10,000-ohm resistive load at 17 milliamperes of d-c input. The results of these tests show that the output is a linear function of the input within $\pm 1/2$ of 1 per cent of the nominal output or ± 0.0175 milliampere. These accuracy limits are maintained for every value of d-c input in the full operating range, 0 to 17 milliamperes.

A single-ended saturable reactor device with such a "to-zero" control characteristic is quite naturally applicable to the field of d-c metering, since it can be a stable, full-range linear, isolating link between industrial d-c power systems and their associated metering and control circuits.

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Digest of paper **54-393**, "Single-Ended Saturable Reactor Circuit with Quiescent Current Compensation," recommended by the AIEE Committee on Magnetic Amplifiers and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 11–15, 1954. Scheduled for publication in AIEE *Communication and Electronics*, 1954.

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Winter General Meeting Offers Full Program of Technical Sessions

This year the Winter General Meeting will be held not only in the Statler, the headquarters hotel, but also in the Hotel Governor Clinton, New York, N. Y., January 31–February 4, 1955.

The technical committees of the Institute are planning another full program of technical sessions and symposiums. Five have already been announced on the subjects of disconnect switches and switchgear. In addition, there will be relays, carrier current, and substations sessions, besides three meetings sponsored by the Committee on Transformers all in the Power Division.

Committees in the Communication Division have completed their preliminary planning and have announced sessions on antennas and propagation, color television, radio communications, communication switching, wire communications, and special communication applications.

In the Industry Division technical meetings on industrial power systems, industrial control, petroleum industry, cathodic protection, electrochemical processes, and chemical industry are being organized.

Other meetings announced are on electronic aids to navigation, semiconductor reliability, basic concepts, nucleonics, and electronic power converters. One important session is being arranged by the Committee on Research, a general committee of the Institute.

Informal Tea

This social gathering before the formal program begins has been enjoyed by more and more people each year. Make it a point to attend this year—Sunday afternoon, January 30, from 4 to 6 p.m., in the Georgian Room of the Statler. There will be no charge.

During this period the registration facilities will be open for those wishing to avoid the Monday morning rush.

HOTEL RESERVATIONS

Blocks of rooms have been set aside at the Statler and nearby hotels for members and guests attending the meeting. Requests for reservations should be sent, prior to January 17, directly to the hotel of choice and to only one hotel. AIEE should be mentioned in the request. If rooms are not available at the hotel of your choice, your request will be referred to the Hotel Accommodations Committee. This committee will then place it with another convention hotel.

Because of the current accommodations situation in New York, reservations for arrival on Sunday, January 30, are suggested. Hotel rooms have been reserved at the following:

Hotel Statler (meeting headquarters), 7th Avenue, 32d to 33d Streets

Single room with bath	$ 6.50 to $11.00
Double room	9.50 to 14.00
Twin bedroom	10.50 to 18.00
Suites	28.00 to 30.00

Hotel New Yorker, 34th Street and 8th Avenue

Single room with bath	$ 6.00 to $12.00
Double room	9.00 to 14.50
Twin bedroom	10.50 to 16.00

Hotel Governor Clinton, 7th Avenue at 31st Street

Single room with bath	$ 6.00 to $ 9.00
Double room	8.50 to 11.50
Twin bedroom	10.50 to 14.50

Hotel McAlpin, Broadway and 34th Street

Single room with bath	$ 4.50 to $ 9.25
Double room	7.00 to 13.50
Twin bedroom	8.50 to 13.50

Hotel Roosevelt, Madison Avenue at 45th Street

Single room with bath	$ 7.50 to $14.00
Double room	12.50 to 17.50
Twin bedroom	15.00 to 20.00

Hotel Martinique, Broadway and 32d Street

Single room with bath	$ 5.00 to $ 7.00
Double room	8.50 to 11.00
Twin bedroom	9.00 to 12.00

Rates are subject to 5 per cent New York City hotel room tax.

SMOKER COMMITTEE

A smoker is scheduled for Tuesday evening, February 1. Attention is called to the fact that the smoker will be held at the Hotel Statler, rather than at the Hotel Commodore as in recent years. Tickets will be $10.00 each. Reservations should be made at an early date and addressed to: Smoker Committee, AIEE Headquarters, 33 West 39th Street, New York 18, N. Y. Those received after January 11 will not be honored.

DINNER-DANCE

Dinner, the President's Reception, and dancing, all in the Grand Ball Room of the Hotel Statler, will climax the social affairs of the Winter General Meeting, Thursday evening, February 3.

Reserve tables for ten, or individual places, by calling or writing soon to AIEE Headquarters, 33 West 39th Street, New York City 18, N. Y. Tickets are $12.00 each and checks should be made to "Special Account, Secretary, AIEE."

INSPECTION TRIPS

A program of inspection trips is being arranged which will include, tentatively, the following places of general and technical interest: Brookhaven National Laboratory, Fairless Plant of the U.S. Steel Corporation, Astoria Generating Station of the Consolidated Edison Company, Bell Telephone Laboratories, Federal Electric Products Plant, Radio City Music Hall, Rambusch Decorating Company, U.S. Navy Materials Laboratory, Edgewater Assembly Plant of the Ford Motor Company, Sylvania Products Plant, New York Stock Exchange, International Business Machines, and United Nations General Assembly Building.

THEATER TICKETS

As in the past, tickets to the following shows currently playing in New York will be available to AIEE members during the week of the meeting. All prices shown are brokers' prices.

	Evenings M, T, W, T	Evenings F, S	Matinees W, S
By the Beautiful Sea (Shirley Booth)	$8.00	$8.00	$5.70
The Boyfriend	8.00	8.00	5.70
Caine Mutiny Court Martial (L. Nolan, J. Hodiak, B. Sullivan)	5.70	6.60	4.95
Can-Can	8.00	8.00	5.70
Comedy in Music (Victor Borge)	5.70	6.85	5.15
Fanny (Ezio Pinza, Walter Slezak)	8.00	8.00	5.70
Kismet (Alfred Drake)	7.70	7.70	4.95
On Your Toes (Vera Zorina, Bobby Van)	8.00	8.00	5.70
The Pajama Game (J. Raitt, J. Page, E. Foy, Jr.)	8.00	8.00	5.70
The Reclining Figure (Mike Wallace, Martin Gabel)	5.70	6.85	4.55
The Solid Gold Cadillac (Sally Forrest)	5.70	6.85	5.15
The Teahouse of the August Moon (Burgess Meredith, Scot McKay)	5.70	7.32	5.13
The Wedding Breakfast (Lee Grant)	5.70	6.85	5.15

Checks should be made payable to: "Theater Ticket Committee, AIEE." Requests also should include first and second choice of both name and date of show, and should be sent to: Theater Ticket Committee, AIEE, c/o S. Friend, Jr., 75 Buena Vista Drive, Dobbs Ferry, N. Y.

LADIES ENTERTAINMENT

The committee is arranging an attractive program which includes a "Get Acquainted" tea on Monday afternoon in Ladies' Headquarters at the Hotel Statler, a dinner and entertainment Tuesday night in the Penn Top, breakfast at Altman's, luncheon and fashion show in the Jade Room, Waldorf-Astoria on Thursday, tour through United Nations Building, as well as tours to other points of interest. Coffee will be served each morning from 9 to 11 a.m. Registration will open in the Georgian Room on Sunday, January 30, from 2 to 4 p.m., and

thereafter each day beginning at 8:30 a.m. in the Ladies' Headquarters.

WINTER GENERAL MEETING COMMITTEE

Members of the 1955 Winter General Meeting Committee are: A. J. Cooper, chairman; D. M. Quick, vice-chairman; J. J. Anderson, secretary; C. S. Purnell, budget co-ordinator; J. P. Neubauer, Vice-President, District 3; J. D. Tebo, chairman, Committee on Technical Operations; R. T. Ferris, public relations; J. R. Kerner, general session; Avery Gould, dinner-dance; W. G. Vieth, hotel accommodations; J. V. O'Connor, inspection trips; Morris Brenner, registration; R. W. Gillette, smoker; R. T. Weil, monitors; S. Friend, Jr., theater and broadcast tickets; Mrs. Merwin Brandon, ladies' committee; C. T. Hatcher, ex officio member (past chairman).

2,008 Attend Fall General Meeting Held in Chicago, October 11–15

The 1954 AIEE Fall General Meeting was held in Chicago, Ill., at the Morrison Hotel, October 11–15. The attendance at this, first of the three Fall Meetings to be held in Chicago, was 2,008 including members, students, and guests. The next two Fall Meetings in Chicago will occur in 1955 and 1956.

Besides the General Session, there were technical sessions, covering a wide gamut of subjects: industrial power systems, air and land transportation, rotating machinery, radio and wire communications, color television and its attendant high-fidelity and magnetic recording, various phases of power generation and distribution, relays, transformers, etc. Because of the number of papers submitted, several subjects had to be covered in more than one session; for instance, air transportation had eight sessions and induction machinery had two, as did higher distribution voltage for metropolitan areas.

On the social side, the Chicago Section was host at a Get-Acquainted cocktail party Monday afternoon. While members enjoyed a smoker on Tuesday evening, the ladies ate at the Kungsholm Restaurant and saw the famous Miniature Grand Opera. The next evening everyone enjoyed the dinner-dance.

On Tuesday, Eta Kappa Nu held a curtain raiser to its 75th anniversary with a luncheon at which Dr. W. L. Everitt, University of Illinois, spoke.

Because of the flood which forced some of the power stations to shut down, the inspection trip to the Ridgeland station had to be cancelled; however, this was the only trip with which the unprecedented high waters in the city interfered.

GENERAL SESSION

The opening General Session was presided over by F. A. Cox, general chairman of the Fall Meeting. He introduced John W. Evers, president, Commonwealth Edison Company, who welcomed the members and their guests. Mr. Evers described the work that electrical engineers had done in his company. He said that those who were most successful had attained versatility in the several phases of the company's activities. Mr. Evers also told of offers which Chicago had made to the engineering societies inducing them to move their headquarters to that city.

The next speaker was AIEE President A. C. Monteith, who spoke about the Institute's financial problems. In the present fiscal year, the Institute will spend about $40,000 more than will be taken in. Next year the deficit will be more than doubled, unless something is done about it. The increase in costs in the Institute's publishing program and its expansion is largely the cause of the deficit and rather than curtail this program in any way, it is to be proposed to the Board of Directors that AIEE dues be increased, something that has not been done for more than half a century.

President Monteith told how the membership has more than tripled since 1922; Sections and Student Branches have doubled in number in the same thirty years, as have both their meetings. He outlined some of the increased costs of serving the membership; for example, in 1922 the cost was $16.77 per member and now this has risen to $24.70. While the Institute has expanded in every way, which is a healthy sign, this expansion has meant increased over-all costs.

The principal address of the General Session was "Technology in Defense," given by AIEE Past President Donald A. Quarles. Mr. Quarles is Assistant Secretary of Defense, Research and Development. He outlined some of the more important technological advances made within the past ten years and showed how engineers are needed for the future strength and welfare of this country. It is important that engineers work toward national policies that enhance and conserve engineering manpower which should be disposed to our greatest national advantage. Engineers should so organize themselves that their voices may be heard in the formulation of national policy relating to their profession, he said.

TECHNICAL SESSIONS

Metallic Rectifiers. That germanium rectifiers are capable of handling large amounts of power was evident from a conference paper presented by E. F. Losco and H. R. Camp of Westinghouse. A unique method of water and vapor cooling made possible continuous operation of six experimental rectifiers, arranged in a 3-phase bridge circuit with a-c power supplied by the transformer and reactor unit of a 300-ampere d-c welder. The rectifier unit was found capable of delivering over 300 amperes at 40 volts d-c. Intentional short circuits put on the unit indicated that surge currents as high as 800 amperes and surge voltages up to 230 volts could be applied with no damage.

A portable magnetically regulated lightweight battery charger for military field applications has been developed, as reported

Future AIEE Meetings

AIEE-IRE-ACM Eastern Computer Conference
Bellevue-Stratford Hotel, Philadelphia, Pa.
December 8–10, 1954
(*Final date for submitting papers—closed*)

AIEE-IRE-NBS High-Frequency Measurements Conference
Hotel Statler, Washington, D. C.
January 17–19, 1955
(*Final date for submitting papers—closed*)

Winter General Meeting
Hotels Statler and Governor Clinton, New York, N. Y.
January 31–February 4, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE Transistor Circuits Conference
University of Pennsylvania, Philadelphia, Pa.
February 17–18, 1955
(*Final date for submitting papers—closed*)

AIEE-IRE-ACM Western Computer Conference
Hotel Statler, Los Angeles, Calif.
March 1–3, 1955
(*Final date for submitting papers—December 1*)

Electrical Utilization of Aluminum Conference
William Penn Hotel, Pittsburgh, Pa.
March 15–17, 1955
(*Final date for submitting papers—December 15*)

Materials Handling Conference
Hotel Cleveland, Cleveland, Ohio
March 28–29, 1955
(*Final date for submitting papers—December 28*)

Rubber and Plastics Conference
Akron, Ohio
April 5–6, 1955
(*Final date for submitting papers—January 5*)

Southern District Meeting
St. Petersburg, Fla.
April 13–15, 1955
(*Final date for submitting papers—January 12*)

Pulp and Paper Conference
St. Petersburg, Fla.
April 14, 1955
(*Final date for submitting papers—January 14*)

Middle Eastern District Meeting
Columbus, Ohio
May 4–6, 1955
(*Final date for submitting papers—February 4*)

Electric Heating Conference
LaSalle Hotel, Chicago, Ill.
May 10–11, 1955
(*Final date for submitting papers—February 10*)

Telemetering Conference
Morrison Hotel, Chicago, Ill.
May 18–20, 1955
(*Final date for submitting papers—February 18*)

AIEE-APS-AIME-CIT Magnetics Conference
William Penn Hotel, Pittsburgh, Pa.
June 14–16, 1955
(*Final date for submitting papers—March 14*)

1955 Summer General Meeting
New Ocean House, Swampscott, Mass.
June 27–July 1, 1955
(*Final date for submitting papers—March 29*)

Shown above are: (left to right) J. W. Evers, president of Commonwealth Edison Company; D. A. Quarles, past president of AIEE and Assistant Secretary of Defense, Research and Development; and A. C. Monteith, AIEE President and vice-president of Westinghouse. All three men played a prominent part in the Fall General Meeting. Mr. Evers welcomed members and their guests; Mr. Quarles gave the principal address of the General Session, "Technology in Defense;" and President Monteith spoke about the financial status of the Institute

in a paper by R. E. D. Anderson, Bell Telephone Laboratories. The charger has a welded aluminum chassis and a field carrying case, and weighs 265 pounds. The basic regulating circuit was adapted from one developed for telephone use, but incorporates a self-saturating magnetic amplifier circuit for line regulation in place of a ferroresonant-type circuit in order to tolerate frequency variations which might occur with portable engine generators.

The Author Meets the Publisher. An innovation was sponsored by the Committee on Electronics in a session devoted to technical writing. The points of view of book and magazine publishers and editors were first presented and then those of two authors who have had their work published on several occasions.

Those responsible for putting out books and magazines are always on the search for good publishable material and are willing to advise and aid authors who demonstrate they have something worthwhile to offer. On the other hand, it was brought out that authors—especially those who have not had much experience—need encouragement. This may well come from older and more experienced engineers in the same company.

In the discussion several men stated that it was their job in their companies to assist young engineers in their writing and to see that they received proper recognition.

Higher Distribution Voltage for Metropolitan Areas. A series of ten technical papers were presented in two sessions concerning the feasibility of providing higher voltages, of the order of 250 and 460 volts, to commercial establishments and buildings in urban areas. This series has been printed as an AIEE special publication, *S-66*.

Nucleonics. The subject of nuclear reactors proved of prime interest as evidenced by the discussion which followed presentation of the six papers at this session. Dr. Stuart McLain, Argonne National Laboratories, gave an over-all picture of reactors which could be used as producers of power. He discussed the different broad classifications of reactors, their coolants, fuels, and the government and industrial programs.

One phase of the subject of nuclear power with which everyone is most concerned is the legal aspects of the recently passed Atomic Energy Act of 1954 and how this law will affect the progress of the art. Stuart MacMackin, General Electric Company, discussed these legal problems. He brought out that under the new Act private enterprise may obtain a better entree, but it is an unknown factor as yet to what extent the Atomic Energy Commission will issue licenses.

Another aspect is the liability for negligence, which the insurance companies are quite skeptical to write policies for. It was thought that a maximum of $10 million would be the limit in the atomic field. Even with all the limitations, this new Act is a step forward.

Two other papers were presented which covered nondestructive testing and the instruments used. Warren McGonnagle, Argonne National Laboratory, listed the various methods of testing, as visual, thermal, radiography, acoustic, magnetic, electrostatic, mechanical gauging, etc., and Robert Swank, of the same agency, presented a paper on the detection of radiation and the scintillation counter.

International Communications. Of outstanding interest was the conference paper "A Transatlantic Telephone Cable" presented by M. J. Kelly, president, Bell Telephone Laboratories, whose co-authors were G. W. Gilman of the Bell Laboratories, Sir W. Gordon Radley and R. J. Halsey, Post Office of the United Kingdom. After tracing the history of communication across the North Atlantic, the inadequacy of radio circuits to satisfy the requirements of traffic growth was discussed. A general description was given of the cable system which will provide 35 telephone circuits across the Atlantic and 60 between Nova Scotia and Newfoundland.

The project has been made possible by the development of submerged repeaters containing vacuum tubes and other components with a life expectancy of 20 years. Fifty two of these repeaters will be used in each of 2-way cables, connecting Newfoundland and Scotland, nearly 2,000 nautical miles away.

Opening the discussion was a recording by Sir Stanley Angwin, former chief engineer, British Post Office, who stressed that the mechanical problems involved in this cable were greater than the electrical ones, as there were always so many things that could occur before, during, and after the cable was laid which could not be anticipated as could those of an electrical nature. Dr. O. E. Buckley, now retired from the Bell Telephone Laboratories and one of the proponents for a cable of this nature, also stated by means of a recording that he thought that such cables would become the backbone of telephonic communication across the Atlantic. He considers the expansion of frequency from 1 cycle per second in the first transatlantic cable to the more than 100 kc of this latest one, a forward step of the greatest importance.

High Fidelity and Magnetic Recording. A 200-watt power amplifier and its power supply was described by F. H. McIntosh, who developed the output circuit of the amplifier. Not only is this equipment usable for reproducing sound, but it can be employed industrially where variable frequency and variable voltages are required. Mr. McIntosh demonstrated his apparatus with all types of recordings which illustrated its versatility.

F. H. Slaymaker, Stromberg-Carlson Company, discussed the general problems of standardization in the electronics industry with special reference to high fidelity. Standards cannot be forced on anyone; they should be gathered slowly, as various angles and aspects are standardized by different organizations, such as the Underwriters Laboratory, the FCC, and others. Above all, Mr. Slaymaker stressed, standards writers should not be reformers.

A survey of magnetic recording was given by S. J. Begun, Clevite-Brush Development Company, in which he traced the development of this type of recording from its inception to the high degree of fidelity and reliability which it has attained today. (See page 1115.)

Color Television and International Broadcasting. Differential phase and gain distortion in color television systems results in a distortion of the transmitted colors. A test set, consisting of a portable transmitter and receiver combination, for measuring differential phase and gain was described by H. P. Kelly, Bell Telephone Laboratories, in the one technical paper of the session. (See p. 799, September 1954.)

E. D. Goodale, National Broadcasting Company, presented "Recording Color Television Programs" in which he reviewed mag-

netic recording of video signals and then the film method, the latter being the backbone of the industry. After a demonstration of films photographed with the new 3-gun camera tube, he explained that most of the recordings now are on 35-mm film, although 16-mm film has been used extensively. Six to eight hours daily are recorded with the ratio between black-and-white recordings and color being about 3 to 1.

One of the most informative papers of the session was presented by George Jacobs, who wrote "The Engineering Development of the Voice of America" in conjunction with E. T. Martin and Julius Ross, all of the U. S. Information Service. The reasons relay stations are needed in foreign countries is that the aurora zone (a circular area several hundred miles in diameter with the magnetic north pole as center) prevents signals from broadcast stations in the United States from reaching those countries at which they are beamed. Recordings of examples of jamming the Voice of America signals were played to the audience after a description of the seventy-odd transmitters located in different parts of the world.

The 1-megawatt long-wave radiobroadcast station at Munich, Germany, was described by J. R. Hall and J. O. Weldon, Continental Electronics Manufacturing Company, and Carl Smith, consultant radio engineer. This Voice of America station uses a directional antenna so that it will not be overwhelmed and consists of two 500-kw transmitters, which can be put on the air separately or together, using a frequency of 173 kc.

Radio and Wire Communications. Twelve technical papers were given in condensed form in one of the final sessions. For the most part these covered military carrier telephone systems and multichannel telegraph and radio telephone systems with descriptions of the circuits and equipment.

Air Transportation. At the eight sessions arranged by the Committee on Air Transportation 17 technical and the same number of conference papers were presented. These ranged in subject matter from considerations of the problems of aircraft rotating machinery and its testing, air turbine drives, use of analogues in jet engine control development, omnirange system for terminal navigation, to the ever-present question of reliability of components of all types.

Visual Output Devices. Two sessions were devoted to this subject with four conference papers given in the first one on printers and plotters, and four on displays and applications in the second. Two papers were given on X-Y recorders covering their history and development; another on a new technique of binary addition; and others were about the Charactron as a computer read-out device, automatic data transfer and display boards, and an aircraft position and identification display.

First Petroleum Industry Conference Acclaimed Success at Tulsa, Oklahoma

An outstandingly successful 3-day technical conference of the new Petroleum Industry Committee was held September 27–29, 1954, with the Tulsa and Oklahoma City Sections as host. Three hundred eighty-nine engineers from 22 states and Canada attended this First Petroleum Industry Conference at the Mayo Hotel, Tulsa, Okla. It was acclaimed by all as filling a vital need in advancing further the art of electrical engineering through technical presentations and discussions of electrical technology and applications. Of 19 technical papers presented, one has already been accorded "*Transactions* status," and it is expected that others will be elevated to this status upon recommendations from the committee. Seven papers were on pipe-line subjects, six on applications in production of oil and gas, four on refining applications, and two were of general interest.

AIEE President A. C. Monteith, who spoke at the conference banquet, launched the committee into a new era of expanding activities and accomplishment. He said:

"Each of us in the electrical industry cannot help but feel proud of the part that electrical energy and electrical equipment has played in the petroleum industry as an important bulwark in the nation's defense and a cornerstone in our economy. We are undergoing an historic transition from a minerals-surplus to a minerals-deficient nation. It is apparent, then, that especially in oil producing and refining operations, every effort must be directed to securing the best possible return from remaining resources."

He pointed out that oil demand in the U. S. is expected to increase from 7–10 million barrels daily in the next ten years, and use of electric power will play a large part in satisfaction of this demand. He estimated that use of electric power by the petroleum industry would increase from 14.8 billion kilowatt-hours of electric energy used in 1953, to 21.5 billion kilowatt-hours by 1963.

The electrical engineer was credited by President Monteith with much of the petroleum industry's technical advancement. Besides the acknowledged fields of electrical application by the petroleum industry, three future fields of expanding importance were singled out: lighting, to insure 24-hour operation safely; communication, which provides for remote operation and control; and electrically operated computers. Regarding computers, he said, "These electrical wizards are saving untold numbers of man hours spent in tedious calculations. In the future, computers will be integrated with complex process controls to provide completely automatic operation. To sum it up, the electrical engineer must not only think, act, and dream in terms of electrical things in his adopted industry, but of economics and progress on a broad plane."

Major A. N. Horne, vice-president, Texas-Empire Pipe Line Company, Tulsa, delivered the keynote address at the conference opening. In response to the welcome address by Tulsa's mayor, L. C. Clark, he urged a "growing up" for electrical engineers. He emphasized that engineers must be considered a part of management. In this new function they must learn to talk the language of management and present problems for decision in language readily understood by management. Co-ordination with other professional engineers also was urged by the speaker.

"The present use and application of electric power by no means is perfect. An electrical engineer should know as much as possible about basic services of engineering in order that he might be better in his own." In the transition from a manual status to that of management, he said the electrical engineer is in a unique position to aid the use and application of electricity as our ever-growing servant.

Oklahoma Governor Johnston Murray was speaker at a luncheon held jointly with The Engineers Club of Tulsa. He advised engineers to be vigilant to retain the rights and liberties of all free peoples. "We need your technical advice for the continued progress of the nation and Oklahoma, and your intelligence for the safe-keeping of those rights and liberties insuring this progress."

Conference Chairman W. H. Stueve was accorded an unusual honor at the banquet.

J. Z. Linsenmeyer, chairman, Petroleum Industry Committee, presents framed AIEE "Fellow Grade" certificate to W. H. Stueve (right). Mr. Stueve's professional record appears on page 1133 in this issue of "Electrical Engineering," under the "AIEE Fellows Elected" heading

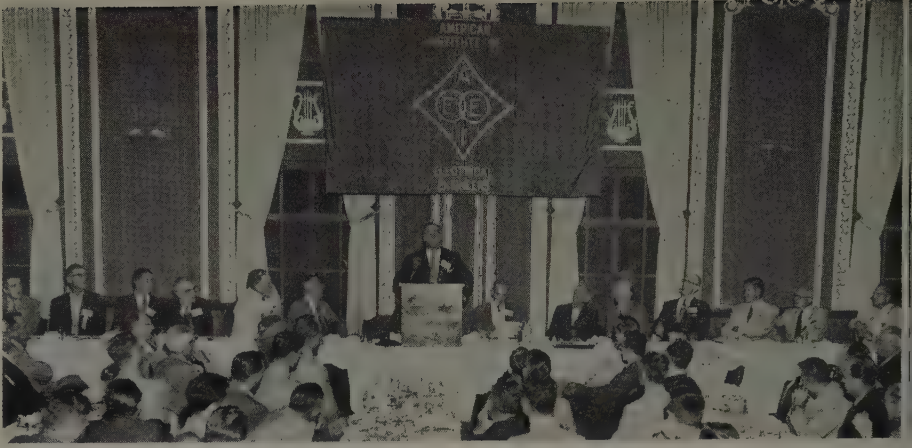
Simultaneous presentations of award of "Fellow" were made to him by both the AIEE and The American Society of Mechanical Engineers (ASME). This makes him the only person in the Southwest who is a Fellow of both organizations. His election to "Fellow" in ASME actually took place in 1947, but a personal presentation was not made until this conference. He was chief electrical engineer during construction of the "Big Inch" pipe-line from Beaumont, Tex., to New Jersey during World War II, and has been called the "father of the use of electric power in the petroleum industry." Mr. Stueve told the conference audience that this First Electrical Conference of the Petroleum Industry was his pet dream for years. He was overjoyed with the enthusiastic response and delighted with the large attendance. In expressing his thanks for the dual honors, he said confidently that AIEE would serve the needs of the industry and grow with the electrical engineers through the Petroleum Industry Committee's expanding activities. Mr. Stueve's award was made by J. Z. Linsenmeyer, committee chairman. Mr. Linsenmeyer acted as master of ceremonies at the banquet. He is with Westinghouse Electric Corporation's Industry Applications Division.

R. F. Danner, AIEE Director, and superintendent of engineering and construction for Oklahoma Gas and Electric Company, introduced President Monteith. He stressed that President Monteith's presence signified intense interest on the part of the Institute in its growth as the agency to represent and serve electrical engineers in the petroleum industry. He urged conference delegates to nurture and support the new committee as the agency for interchange of electrical technology and "know how" in co-operation with paralleling groups, such as the American Petroleum Institute and the Petroleum Division of the ASME, so that the full stature of the electrical engineer within the petroleum industry may be realized.

The banquet ended on a note of levity when President Monteith was presented with a scroll signed by Governor Murray. It was affixed with the great seal of the State of Oklahoma which proclaimed that "A. C. Monteith was hereby commissioned as Commodore in the Oklahoma Navy." To prove it, Mr. Linsenmeyer presented him with a commodore's cap decorated in gold braid and encrusted with gold ornament.

On the third day of the conference, Mr. Linsenmeyer announced the formation of three subcommittees. Head of the Production Subcommittee is J. R. Ashley, Magnolia Pipe Line Company, Dallas, Tex.; chairman of the Transportation Subcommittee is R. S. Cannon of Plantation Pipe Line Company, Atlanta, Ga.; and chairman of the Refining Subcommittee is W. H. Dickinson of Standard Oil Development Company, Linden, N. J. Tentative dates set for the next conference are September 13–15, 1955, at Houston, Tex., with Dallas as the alternate city.

Because of the demand for copies of the papers, consideration is being given to reprinting all the papers in one volume. This would be made available through headquarters at nominal cost. Notice of availability will be published in *Electrical Engineering* within a few months.



President A. C. Monteith is shown addressing the First Electrical Conference of the Petroleum Industry in Tulsa, Okla., September 28. At the speakers' table are: (left to right) Professor D. L. Johnson, AIEE Student Branch Counselor, Oklahoma Agricultural and Mechanical College, and chairman of student participation; M. C. Callahan, chairman, registration and hotel arrangements; J. H. Heller, chairman, Tulsa Section; R. J. Thompson, past chairman, Oklahoma City Section, and member-at-large for conference; V. J. Sittel, vice-chairman, Petroleum Industry Committee, vice-chairman of the conference; President Monteith; J. Z. Linsenmeyer, chairman, Petroleum Industry Committee; W. H. Stueve, conference chairman; R. S. Gardner, assistant secretary, technical activities, AIEE Headquarters; A. N. Horne, keynote speaker; A. H. Newberg, member, Executive Committee, Petroleum Division of The American Society of Mechanical Engineers; W. F. Hildebrand, chairman, finance and budget for conference; H. M. Furtney, chairman, regional publicity for conference

Annual AIEE Prizes in Various Classifications

The following is a reminder of the awards which are available each year in each classification:

1. *Institute*

Class	First Prize	Additional Prize
(*a*). Each Division: Communication, General Applications, Industry, Power, Science and Electronics	$100 and certificate	Certificate (In special cases additional certificates may be awarded at the discretion of the Committee on Prize Awards for Institute papers.)
(*b*). Paper outside Division jurisdiction	$100 and certificate	None
(*c*). Best Student paper	$100 and certificate	Certificate

2. *District*

Class	First Prize	Additional Prize
(*a*). Best paper, any class	$75 and certificate	$50 and certificate
(*b*). Best paper presented by undergraduate Student member in District competition	$25 and certificate	Certificate

3. *Section*

$100 to be divided at the discretion of the Section, with a maximum of $50 for any one prize, and certificate for each winner.

4. *Branch* (*Undergraduate*)

Class	First Prize	Additional Prize
(*a*). Best paper	$10 and certificate plus an allowance of 13 cents per mile one way for 800 miles or less and 10 cents per mile one way for remaining distance to the District Student prize paper competition	Certificate

The complete rules for the award of prizes for AIEE technical papers appear in the September 1954 issue of *Electrical Engineering* (pages 825–6).

AIEE Board of Directors Meeting Held in Chicago, Ill., October 14

A regular meeting of the AIEE Board of Directors was held in the Morrison Hotel, Chicago, Ill., on October 14, 1954.

BOARD OF EXAMINERS

Recommendations adopted by the Board of Examiners at its meeting held on September 16, 1954, were reported and approved, including the following: 115 applicants transferred, 10 elected, and 4 re-elected to the grade of Member; 5 applicants transferred, 248 elected, and 25 re-elected to the grade of Associate Member; 55 applicants elected to the grade of Affiliate; 48 Student members enrolled.

The Board of Examiners submitted three proposals for transfer to the grade of Fellow with a favorable recommendation and a recommended citation in each case. The Board of Directors voted to invite the three Members to be transferred to the grade of Fellow, as follows:

Mr. Bell Alexander Cogbill, development engineer, General Electric Company, Pittsfield, Mass.

Mr. Elmer Francis De Turk, electrical engineer, Long Island Lighting Company, Mineola, N. Y.

Mr. Laszlo Istvan Komives, assistant general superintendent, Underground Lines Department, The Detroit Edison Company, Detroit, Mich.

More informationr egarding the aforementioned individuals will appear in *Electrical Engineering* in the department "AIEE Fellows Elected" in a subsequent issue.

FINANCES

Walter J. Barrett, AIEE Treasurer, submitted a report for the first five months of the fiscal year, beginning May 1, 1954, and ending September 30, 1954, which was accepted by the Board.

Chairman C. S. Purnell of the Finance Committee reported disbursements from general funds as follows: August—$80,604.87; September—$74,016.43. The report was approved.

A budget for the appropriation year ending September 30, 1954, as recommended by the Finance Committee, was submitted by Chairman Purnell, and was adopted by the Board.

ACTIONS AND APPOINTMENTS

Upon recommendation of the Committee on Planning and Co-ordination, the Board of Directors authorized the holding of a North Eastern District No. 1 Meeting in Pittsfield, Mass., May 1–3, 1957.

The Sections Committee recommended and the Board approved the establishment of the Savannah Section, from the Savannah Subsection of the Georgia Section.

Members of the Board of Directors were selected as members and alternates to represent the Board on the AIEE Nominating Committee, as follows:

Members: D. I. Cone, D. D. Ewing, E. S. Lammers, J. P. Neubauer, E. W. Seeger.

Alternates: G. J. Crowdes, J. H. Foote, A. C. Muir.

The Board voted to accept the invitation to join the International Science Foundation as a participating member in the National Science Foundation for a period of one year without financial obligation.

A feature of this meeting of the Board of Directors was a luncheon talk by Leo E. Brown, director of public relations for the American Medical Association (AMA). Mr. Brown outlined for the Board the organization and policies of AMA and answered many questions about the society.

The Board accepted the invitation of the Society of the American Military Engineers to serve as one of the co-operating agencies in its Midwest Conference of February 10 and 11, 1955, and to call the attention of the organization to the fact that AIEE is a member of Engineers Joint Council and a participant in the Engineering Manpower Commission of that Council, and is of the opinion that the Engineering Manpower Commission could contribute materially to the success of the conference.

The question came up as to the feasibility of reporting back to the Sections on the actions of the Board of Examiners in rejecting applications for membership or transfer. The President explained that the policy of the Institute, in this respect, is to inform the Section of such action only when the application is submitted through the Section membership or transfers committees.

The next meeting of the Board of Directors will be held on February 3, 1955, during the Winter General Meeting in New York, January 31–February 4, 1955.

ATTENDANCE

Present at the meeting were: *President* A. C. Monteith; *Past President* Elgin B. Robertson; *Vice-Presidents* C. P. Almon, Jr., A. S. Anderson, G. J. Crowdes, G. D. Floyd, Walter B. Morton, J. P. Neubauer, S. M. Sharp, C. M. Summers, G. C. Tenney; *Directors* F. R. Benedict, Donald I. Cone, R. F. Danner, D. D. Ewing, J. H. Foote, L. F. Hickernell, R. E. Kistler, E. S. Lammers, Jr., T. M. Linville, A. C. Muir, C. S. Purnell, E. W. Seeger; *Treasurer* Walter J. Barrett; *Secretary* N. S. Hibshman.

Outstanding Middle Eastern District Meeting Held in Reading, Pa.

The Middle Eastern District's meeting at the Abraham Lincoln Hotel in Reading, Pa., October 5–7, 1954 was outstanding from the points of view of attendance, which was 905, the high quality of the papers, and the excellent entertainment afforded members, their ladies, and guests.

Following the theme of the meeting, "Electric Power Supply and Utilization—Major Industries of the Pennsylvania Dutch Country," 20 sessions were conducted on power, transmission and distribution, substations, plant safety, and relays—with special attention directed toward sessions on mining and quarrying, steel, textiles, and general industrial subjects.

The General Session on Tuesday was reported in November *Electrical Engineering*, page 1030. For Mr. W. V. O'Brien's address, see page 1062 of this issue.

On the second day of the meeting, AIEE President A. C. Monteith addressed a students' luncheon attended by more than 200 men from engineering colleges in the District.

In his address, President Monteith emphasized that corporations of all sizes were searching constantly for young engineers of managerial calibre. After speaking about the characteristics they should cultivate, such as loyalty, determination, willingness to accept responsibility, etc., Mr. Monteith said the biggest question to which a man had to find an answer was: Did he want an opportunity to progress, or job security? Engineers should choose the former, he said, for early in his career, he is really working for himself and should accept all challenges. Education is a journey and not a destination; it must be continued after starting to work. Advice from superiors in a company should be followed and, if available, a managerial course should be taken. The young engineer should identify himself with his community life and assume responsibility in government.

SOCIAL ACTIVITIES

On Tuesday evening, there was a Fersommling—a Pennsylvania Dutch smorgasbord—enjoyed by members and their guests. They were entertained by a group of local hoe-down dancers. After the banquet held the next evening, entertainment was furnished by the "Textilaires," a choral group, followed by dancing.

A special ladies' program was provided including visits to Berkshire Knitting Mills and to Hershey, Pa.

TECHNICAL SESSIONS

One of the sessions of local interest was that devoted to mining and quarrying. Three of the four conference papers were concerned with the development and problems encountered in the nearby zinc, limestone, and iron mines; the fourth paper was devoted to the design of the electric equipment at Grace Mine.

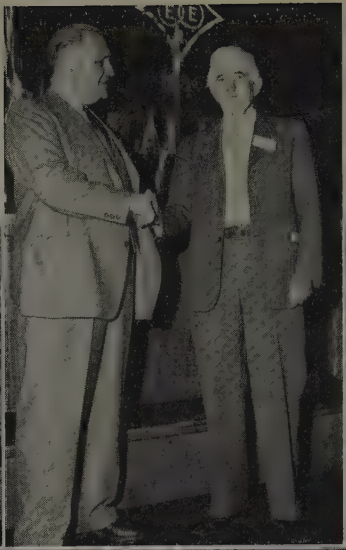
Six conference papers on textiles occupied two sessions. The first three papers dealt with the knitting of ladies' stockings and the drives of the knitting machinery. These must be variable because of the different speeds at which parts of the stockings are knit. Instead of using two drives, one all-electronic and one with an electronically controlled motor-generator set, the latest has an amplistat regulated-speed variator with no electron tubes. The other three textile papers were about other types of machine drives.

In the field of communication and television, four conference papers were given. Dr. W. J. Pietenpol, Bell Telephone Laboratories, told about new transistors, which have functioned in the 500-mc region, and which have a theoretical top of 3,000 mc. Tests

Meeting Highlights

Middle Eastern District Meeting

Reading, Pa., October 1954



Picture at top left: (left to right) AIEE President A. C. Monteith; F. H. Lichtenwalter, former managing director of the Pennsylvania Electric Association who was luncheon speaker at the General Session; and W. B. Morton, vice-president of the Middle Eastern District. Center photo: AIEE Secretary N. S. Hibshman greets one of the Institute's oldest members, Taylor Reed, 87, of Reedsville, Pa. Mr. Reed, who joined AIEE in 1911, drove more than 100 miles to attend the meeting. He has taught at Princeton and was with General Electric Laboratories in Schenectady. At top right: the Executive Committee Meeting held October 4 in the Berkshire Hotel's Walnut Room. Left to right: E. C. Cubbe, chairman, District Committee on Student Activities, A. C. Monteith, AIEE President; N. H. Sheppard, District representative, Sections Committee; W. B. Morton, District vice-president; L. L. Nonemaker, District secretary. Scene at bottom left: Hotel Abraham Lincoln Lobby where members bought papers, met friends, and lounged. Center bottom picture: The Ladies' Tea took place in the Hotel Abraham Lincoln's English Lounge, October 4. Pouring tea is Mrs. M. F. Rosol. Co-chairwomen of tea were Mrs. Rosol and Mrs. George Early. Bottom right: The Students' Lunch took place October 6, in the Abraham Lincoln Hotel's ballroom. Total student registration was 117. At head table are D. L. Green, Lehigh Valley Section chairman; W. B. Morton, District vice-president and General Committee chairman; President A. C. Monteith, main speaker; F. W. Smith, chairman Student Committee; C. T. Pearce, District vice-presidential nominee; R. E. Neidig, General Committee vice-chairman; L. L. Nonemaker, District secretary; and F. S. Fehr, Registration Committee chairman

have been run in card translators, digital computers, and in rural carrier work. The rates of failure of hundreds of transistors have been only a small fraction of 1 per cent per hour. This shows that reliability is steadily increasing. F. H. Bower, Western Electric Company, described the "zone" process used in the refining of germanium for transistors. The economic factors involved in the design of an ultrahigh-frequency television transmitter were dealt with by L. W. Haeseler, Radio Corporation of America, in describing the 12.5-kw station at WBRE-TV, Wilkes Barre, Pa. The principles underlying color television were demonstrated by C. N. Hoyler, RCA Laboratories.

Although presented in a session on power, a description of a power-plant communication system was given by A. R. Royle, Gai-Tronics Corporation. This system can be used in paging or as an ordinary intraplant telephone. It is so designed that no sound-reducing booths are needed.

Three sessions were given over to power problems at which 13 papers were presented. Of local interest was the description of the new Martins Creek steam electric station of the Pennsylvania Power and Light Company, and another paper by W. B. Morton of the same company concerning field-welded generator lead housings. Two related papers on all-steel station grounding network and the impedance and induced voltage measurements were given by S. J. Litrides and W. F. Mackenzie, respectively.

The ultrasonic flowmeter was described in a paper by R. C. Swengel, W. B. Hess, and S. K. Waldorf and was demonstrated by the use of a flow of air instead of a liquid. (See page 1082 of this issue.)

Seven conference papers were given in two sessions on industrial applications. Subjects covered in the first session were oil-cooled d-c magnets, heat pump design for an office building, and transverse flux induction heating. The development of fluorescent lamps was traced by Dr. E. F. Lowry, Sylvania Electric Products, Inc. He said there has been an increase in the efficiency of luminous lamps in the past eight years: the efficiency of the 8-foot 1.5-inch tube is better than 70 per cent. Phosphors also have been improved, as has the life from 4,000 hours to 7,500 hours in 1953. Another paper which proved of interest was the description by A. Zack and J. C. Heffernan of Sylvania, on the automatic method of producing wafer coils for small power transformers. This is done by winding wide strips of metal foil and thin insulation on a form and then cutting the roll into appropriate widths to form the coil. A moving picture of the laying of the pipe line across the Straits of Mackinac ("The Deep Inch") concluded the second session.

Two sessions on the steel industry were held in which different types of electric furnaces and their operation were described. On the final meeting day two sessions on substations were held, and also sessions on management, relays, and carrier current, and problems in the generation of electric power by nuclear energy.

High-Frequency Measurements Conference To Be Held Next Month in Washington

The fourth meeting of the Conference on High-Frequency Measurements will be held January 17–19, 1955, in Washington, D. C. Headquarters for the conference will be the Hotel Statler. All sessions will be held in the Department of the Interior Auditorium.

This meeting, which has become a biennial affair, presents the latest advances in the art of radio measurements. The 1955 meeting will be sponsored by AIEE, the Institute of Radio Engineers, the International Scientific Radio Engineers, the International Scientific Radio Union, and the National Bureau of Standards. The conference program follows:

Monday, January 17

9:30 a.m. Registration, Hotel Statler

1:30 p.m. Technical Session I. Measurement of Transmission and Reception

Presiding: B. Parzen, Olympic Radio & Television Company

Measurements and Components for Rectangular Multimode Waveguides. *D. J. Angelakos*, University of California

A Comparison Method for Tuning Wideband Transmitting Tubes. *H. H. Rickett*, Wheeler Laboratories. Inc.

Radio Interference Measurement Techniques. *L. W. Thomas*, Bureau of Ships, Navy Department

Pattern Measurements of Large Fixed Antennas. *J. P. Shanklin*, Collins Radio Company

Accurate Radar Attentuation Measurements Achieved by In-Flight Calibration. *F. J. Janza, R. E. West*, Sandia Corporation

Use of Distribution Curves in Evaluating Microwave Path Clearance. *B. F. Wheeler, H. R. Mathwich*, RCA Electronic Products Division

Tuesday, January 18

9:30 a.m. Technical Session II. Measurement of Power and Attenuation

Presiding: E. W. Houghton, Bell Telephone Laboratories

6-Kmc Sweep Oscillator. *D. A. Alsber*, Bell Telephone Laboratories

Data on Temperature Dependence of X-Band Fluorescent Lamp Noise Sources. *W. W. Mumford, R. L. Schafersman*, Bell Telephone Laboratories

Broadband UHF and VHF Noise Generators. *W. H. Spencer, P. D. Strum*, Airborne Instruments Laboratory

A Noise Meter Having Large Dynamic Range. *P. D. Strum*, Airborne Instruments Laboratory

Precise Insertion Loss Measurements Using Imperfect Square Law Detectors and Accuracy Limitations Due to Noise. *B. O. Weinschel*, Weinschel Engineering Company

Microwave Peak Power Measurement Techniques. *R. E. Henning*, Sperry Gyroscope Company

12:15 p.m. Luncheon Hotel Statler*

Presiding: R. V. Lowman, Chairman, Joint AIEE-IRE Committee on High Frequency Measurements

Guest Speaker: The Honorable Donald A. Quarles, Assistant Secretary of Defense for Research and Development

* $4.50 per person

2:00 p.m. Inspection trip

Chartered busses leave from Hotel Statler for Bureau of Standards, Naval Observatory, Naval Ordnance Laboratory, Naval Research Laboratory. (The Naval Ordnance and Naval Research Laboratories are restricted to citizens of the U.S.A.)

8:15 p.m. Demonstration Lectures, Interior Department Auditorium

This evening session is sponsored jointly by the Conference Committee and the Washington Sections of the AIEE and IRE

Presiding: J. W. Kearney, Airborne Instruments Laboratory

Engineers Are People. *G. H. Brown*, Radio Corporation of America

An Excursion in Electronics. *C. N. Hoyler*, Radio Corporation of America

Wednesday, January 19

9:30 a.m. Technical Session III. Measurement of Impedance

Presiding: A. A. Oliner, Polytechnic Institute of Brooklyn

Application of UHF Impedance Measuring Techniques in Biophysics. *H. P. Schwan*, University of Pennsylvania

Representation and Measurement of a Dissipative Four-Pole by Means of a Modified Wheeler Network. *H. M. Altschuler*, Polytechnic Institute of Brooklyn

The Use of Concentric-Line Transformers in UHF Measurements. *W. A. Harris, J. J. Thompson*, Radio Corporation of America

Figure of Merit of Probes as Standing Wave Detectors. *S. W. Rubin*, Polytechnic Research and Development Corporation; *M. Wind*, Polytechnic Institute of Brooklyn

Characteristics of Microwave Comparators. *E. W. Matthews*, Sperry Gyroscope Company

A Comparison Method for Measuring Cavity Q. *E. B. Mullen, P. M. Pan*, General Electric Company

2:00 p.m. Technical Session IV. Measurement of Frequency and Time

Presiding: B. M. Oliver, Hewlett-Packard Company

A Portable Frequency Standard for Navigation. *P. Antonucci*, Rome Air Development Center; *J. O. Israel, E. B. Mechling, F. G. Merrill*, Bell Telephone Laboratories

Locked Oscillators in Frequency Standards and Frequency Measurement. *J. K. Clapp*, General Radio Company

Measurement of the R-F Frequency and R-F Pulses. *A. Bagley, D. Hartke*, Hewlett Packard Company

An Instrument for Precision Range Measurements. *D. H. Beck*, Hazeltine Electronics Corporation

6-KMC Phase Measurement System for Traveling Wave Tubes. *C. F. Angustine, A. Slocum*, Bell Telephone Laboratories

A Precision X-Band Phase Shifter. *E. F. Barnett*, Hewlett-Packard Company

AIEE Members Take Prominent Part in Twenty-Second Annual ECPD Meeting

The Twenty-Second Annual Meeting of ECPD (Engineers' Council for Professional Development) was held in Cincinnati, Ohio, October 28–29, 1954, with headquarters in the Alms Hotel. The first day of the meeting was devoted to council business, meetings of the standing committees, presentation of reports, and election of officers. The second day of the meeting was devoted to a report of the Training Committee and panel discussions of the community project in professional development, which has been so successful in Cincinnati, and is headed by Professor Cornelius Wandmacher, (ASCE), through the co-operation of the University of Cincinnati, the engineering societies, and the local industries. President A. C. Monteith led off with introductory remarks, and was followed by Ernest S. Fields, chairman of the Cincinnati sponsor group, and Walter A. Draper, president of the Herman Schneider Foundation. The points of view of well-known educators, the participating societies, and the local industries were expressed by speakers who comprised the panels. In the afternoon, a session was held on present and projected community projects in professional development. It is of interest to note that James W. Parker, retired president of the Detroit Edison Company, was chairman of ECPD when the training program was initially launched and he was one of those who originally conceived the idea.

ELECTION OF OFFICERS

Colonel L. F. Grant was re-elected president; M. D. Hooven (AIEE) was elected vice-president, and serves as vice-president of the Executive Committee and chairman of the Finance Committee. The office of chairman and vice-chairman was changed to the more appropriate title of president and vice-president. D. D. Ewing (AIEE) was reappointed to the council. S. L. Tyler (AIChE) was elected secretary of the council and he will also serve as secretary of the Education Committee. He is admirably equipped to serve this Committee because of his long experience with accrediting. AIChE was the original pioneer in accrediting of chemical engineering curricula before ECPD was organized.

The following AIEE members were elected:

Guidance Committee

S. Paul Shackleton, chairman.

M. S. Coover, W. R. Grogan, and J. H. Lampe.

Education Committee

Harold L. Hazen, chairman.

E. C. Easton, W. L. Everitt, and J. C. Calvert.

Student Development Committee

Lee H. Hill and W. J. Seeley.

Training Committee

J. H. Foote and Guy Kleis.

Recognition Committee

R. T. Warner, chairman.

G. H. O'Sullivan and R. W. Sorensen.

ANNUAL DINNER

The feature of the annual dinner was an address, "The National Manpower Outlook

From the Point of View of the Professions" by James H. Taylor, Assistant Director for Manpower, Office of Defense Mobilization, and director of industrial relations, The Proctor and Gamble Company. Greetings were expressed by Dr. Raymond Walters, president, University of Cincinnati. Three past chairmen of the council, Everett S. Lee (AIEE), James W. Parker, and Harry S. Rogers were present, as well as the presidents of constituent societies or their representatives. M. D. Hooven presided and a resolution of thanks and appreciation to all those concerned with the community project in Cincinnati, the sponsors, local sections, societies, and the university was read by F. J. Van Antwerpen.

Engineers' Council for Professional Development (ECPD) was organized to enhance the professional status of the engineer through the co-operative efforts of the following national organizations who are constituent members concerned with the professional, technical, educational, and legislative phases of engineers' lives: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, Engineering Institute of Canada, American Society for Engineering Education, American Institute of Chemical Engineers, and the National Council of State Boards of Engineering Examiners. ECPD is best known for its work of accrediting technical curricula in the engineering colleges. Vice-President C. M. Summers, AIEE Great Lakes District, who attended the meeting, was so impressed with the work of ECPD and its program that he asked to serve on one of the committees.

Many AIEE members have served as president of Eta Kappa Nu Association. Past presidents who attended the assocation's Golden Anniversary Meeting at the University of Illinois (Urbana) last October are shown above. AIEE members are indicated by their AIEE membership status. Top row: (left to right) R. I. Wilkinson, AM '35; G. H. Kelley; F. E. Sanford, F '46; N. S. Hibshman, AIEE Secretary, F '41; A. A. Hofgren; G. P. Sawyer; O. H. Loynes, AM '20; N. L. Best, AM '46. Middle row: (left to right) W. E. Kock; D. G. Evans, M '40; T. W. Williams, M '52; L. A. Spangler; F. E. Brooks, F '48; H. S. Cocklin; F. E. Harrell, F '40; F. X. Burke. Front row: (left to right) J. W. Weight, M '26; O. W. Eshbach, F '37; A. M. Buck, F '23; E. S. Lee, past AIEE president and newly inducted eminent member of Eta Kappa Nu, F '30; E. T. B. Gross, chairman of the Golden Anniversary Meeting, F '48; J. E. Hobson, Eta Kappa Nu president, F '48; A. B. Zerby, Eta Kappa Nu executive sectretary, AM '38; E. B. Kurtz, F '29; Robin Beach, F '35

Golden Anniversary Is Celebrated By Eta Kappa Nu Association

Approximately 300 Eta Kappa Nu members, including delegates from 65 colleges and alumni chapters, gathered at the University of Illinois (Urbana) October 15 and 16 to celebrate the electrical engineering honor society's fiftieth anniversary. They were joined by 50 guests representing college and industrial interests in the electrical engineering profession. Eta Kappa Nu was founded at the University of Illinois on October 28, 1904, for "closer co-operation amongst students and others in the electrical engineering profession who, by their attainments in college or in engineering practice, manifest exceptional interest and marked ability."

Dr. W. L. Everitt, of the University of Illinois, was toastmaster at a banquet held on the second day of the convention, and Dr. J. E. Hobson, national president of the association, was main speaker. Dr. Hobson described the shortage of scientific manpower in the free nations as opposed to the advances made in countries under Soviet domination. In his address Dr. Hobson said:

"As we scan our technical resources in terms of people, we are confronted with disquieting statistics. To be blunt, we are losing ground badly. There is, furthermore, no prospect of catching up in the immediate future. Available figures are straightforward in support of that alarming view. In this country, we are now replenishing our technical manpower reservoir at the rate of less than 20,000 yearly. That is a record low for recent years, continuing a steady decline from a peak of 52,000 in 1950.

"The output of the technical schools can be expected to rise to about 34,000 in another three years. That is a happy trend, but not happy enough. Russia is currently producing about 50,000 trained men and women annually. The unfavorable ratio, now two and a half to one, is growing, and we may soon find ourselves hopelessly outstripped."

Dr. Hobson said the best-founded estimates are that the present number of research scientists and engineers in Russia is already approximately equal to the number in our country—some 250,000 to 300,000.

A highlight of the meeting was the rededication of a silver anniversary memorial plaque, transferred to a location near the new Electrical Engineering Building. At this rededication, brief talks were given by Ellery B. Paine, professor and chairman of electrical engineering at Urbana for many years and now professor emeritus; Everett S. Lee, past president of AIEE and Eta Kappa Nu, and University of Illinois alumnus; William T. Burnett, one of the association's founders whose name appears on the silver anniversary plaque; and Dr. S. Reid Warren, national vice-president of Eta Kappa Nu. Messrs. Lee and Paine, as well as Dr.

Admiring Eta Kappa Nu's Silver Anniversary Plaque are: (left to right) E. B. Paine, professor emeritus, electrical engineering, University of Illinois; E. S. Lee, AIEE and Eta Kappa Nu past president; W. T. Burnett, a founder of Eta Kappa Nu; Dr. S. R. Warren, Eta Kappa Nu's national vice-president. The plaque was relocated and rededicated during the Golden Anniversary Meeting

A. A. Potter of Purdue University, were inducted as eminent members.

Among those participating in the Golden Anniversary Meeting were many of the honor society's past presidents and national officers, including Dr. Eric T. B. Gross, chairman of the General Meeting Committee and immediate past president; and Alton B. Zerby, executive secretary. Welcome addresses were given by Donald J. Heid, president of the student chapter at the University of Illinois, and Dr. E. C. Jordan, professor and chairman of electrical engineering at the University. Local convention arrangements were in the hands of Professor D. S. Babb.

Three Trips Made in One Day by AIEE-IRE Missouri Mines Branch

On October 9, more than 55 members of the AIEE-IRE Missouri School of Mines Joint Student Branch left Rolla for the first field trip of the school year.

First stop was the Missouri State Highway Patrol Communication Center at Jefferson City. Then the group visited the University of Missouri's television station, KOMU-TV, near Columbia.

On the return trip to Rolla, they stopped at the American Telephone and Telegraph Company's radio relay tower near Holt Summit, and were given a guided tour through the facilities.

Two days prior to this trip, on October 7, the regular business meeting was held with more than 85 students in attendance. An address was given by B. J. George, power consultant for Kansas City Power and Light Company. Mr. George's subject was "A Wider Horizon for Engineers."

Other plans have already been made for programs through the month of February.

AIEE Machine Tool Conference Held in Detroit Oct. 25–27

Eight papers on automation, preventative maintenance, electronic controls, and a panel discussion on electric clutches were featured at the seventh annual AIEE Special Conference on Machine Tools at the Statler Hotel, Detroit, Mich., October 25–27. AIEE's Subcommittee on Machine Tools and the Detroit Section were sponsors.

Kurt O. Tech, of the Cross Company, Detroit, was general chairman, and R. E. Stroppel, of the Tool Steel Gear and Pinion Company, Cincinnati, Ohio, was vice-chairman.

At a banquet Monday, October 25, Dr. Kenneth McFarland, educational consultant to General Motors Corporation, was speaker. Dr. Henry J. Gomberg addressed an informal luncheon on Tuesday. Dr. Gomberg is assistant director, Michigan Memorial–Phoenix Project on Peacetime Applications and Implications of Atomic Energy.

Four papers on automation were presented at the Monday, October 25, session. E. E. Opel, of the National Automatic Tool Company, presided. The papers were: "Automation Today," P. H. Alspach, General Electric Company; "Standard Automation and Inspection of Equipment," by M. M.

Lynn Section's Program Features Travelogues

Officers of the Lynn Section, Mass., have planned an interesting program for this year: an imaginary trip to India, a tale of the lost Incas of Peru, a Burton Holmes travelogue of Australia and New Zealand, and a journey through Brazil. These travelogues, plus twelve science lectures and four inspection trips, will make this season's program one of the finest ever offered by the Section. Seated, left to right: J. R. Macintyre, Section chairman; E. K. Rohr, past chairman. Standing, left to right: F. O. MacFee, Jr., secretary-treasurer; S. W. Stawicki, vice-chairman; D. M. Longenecker, assistant secretary-treasurer

Michigan Section Hears Swiss Speaker

More than 200 engineers heard Mr. Wernor R. Streuli, Brown Boveri and Company, Baden, Switzerland, discuss power distribution of a typical Switzerland utility at a recent dinner meeting of AIEE's Michigan Section. Shown in the above photo are (left to right): H. R. Armstrong, Section secretary-treasurer; J. H. Foote, AIEE Director; F. Von Voigtlander, Section vice-chairman; Speaker Streuli; and J. J. Carey, Section chairman

Arlin, Arlin Products; "Automation Maintenance," Norman K. Conrad, Ford Motor Company; and "Trends in Automation," Ralph E. Cross, the Cross Company.

F. L. Fisher, the Allen-Bradley Company, presided at the Tuesday afternoon session, at which the following papers were presented: "Techniques in Failure Prevention," J. H. Hosmer, Allis-Chalmers Manufacturing Company; "A Preventative Maintenance System and Its Execution," L. P. Randall, Turnstedt Division, General Motors Corporation; "Record Playback Control of Hypro Skin Mill," H. E. Ankeney, Giddings and Lewis Machine Tool Company, and John L. Dutcher, General Electric Company.

Presiding over the Wednesday morning session was E. L. Behringer of the Micromatic Hone Corporation. Papers featured were: "Increasing Reliability of Industrial Electronic Controls," A. V. Wise and J. W. Picking, Reliance Electric and Engineering Company. There was also a panel discussion on electric clutches. Panel members were H. B. Stallings, I-T-E Circuit Breaker Company; John B. Brown, Jr., Warner Electric Brake and Clutch Company, and W. G. Martin, Vickers Electric Company.

In addition to the technical program, inspection trips were made to plants of the Ford Motor Company, the U. S. Rubber Company, Excella Corporation, and the Detroit Transmission Division of General Motors Company, and to the Henry Ford Museum and Greenfield Village.

G. E. Herrmann Succeeds Norris as Office Manager for AIEE

George E. Herrmann, formerly chief accountant and assistant office manager of the American Institute of Mining and Metallurgical Engineers (AIME), has been appointed Office Manager of the AIEE to succeed F. A. Norris who retired recently after 50 years of service (*EE, Nov '54, p. 1031*). His appointment became effective on November 1, 1954.

Mr. Herrmann, who resides in Bellmore, N. Y., was graduated from the Pace Institute in 1939. He was employed by the National City Bank of New York as a bookkeeper from 1935 until 1939 when he joined Pan American–Grace Airways for whom he worked as chief accountant in their New York, N. Y., office and assistant chief accountant in their Lima, Peru, office.

In his capacity as chief accountant and assistant business manager for the AIME, with whom he became affiliated in 1951, Mr. Herrmann inaugurated several new procedures and improved various accounting methods, including the institution of a completely new basis of recording of income and expenses. He also instituted the "Quarterly Investment Report of Endowment and Custodian Funds."

G. E. Herrmann

1955 AIEE-IRE Conference Planned on Transistor Circuits

The Science and Electronics Division of AIEE, the Institute of Radio Engineers' Professional Group on Circuit Theory, and the University of Pennsylvania are jointly sponsoring a Conference on Transistor Circuits, to be held on Thursday and Friday, February 17 and 18, 1955, at the University of Pennsylvania in Philadelphia.

Rapid strides have been made in the transistor art since the last circuits conference held in Philadelphia early this year, and the 1955 conference will attempt to cover this broad advance. Papers dealing with current trends in both linear and pulse circuit techniques as they affect various fields of application will be included. As in the past, the conference is designed to appeal primarily to engineers working actively with transistor circuits.

Registration material for the conference will be ready for mailing early in January, and details of the registration procedure will be announced at that time.

Tau Beta Pi Convention Held In October

Tau Beta Pi's 49th national convention was held at Iowa State College (Ames) from October 21–23. Official host was the Iowa Alpha chapter at the college, and all 96 collegiate chapters were represented. Tau Beta Pi President E. R. Moore, assistant manager of engineering for the Detroit Edison Company, and President-elect Harold M. King, retired turbine engineer for General Electric at Lynn, Mass., also attended.

For the second successive year, the convention voted to admit women to membership. This action is subject to ratification by the undergraduate members of the association. In 1953 the proposal was defeated by student balloting. If this year's action is again nullified by the ratification vote, chapters will still be able to award special women's badges to those who meet the same scholarship and character qualifications required of men for membership. During the past 20 years 174 women have been honored. The most recent one was Mary Louise Schulze, State University of Iowa, who received her badge at the 1954 Convention initiation banquet.

Other Constitutional and Bylaws changes dealing with Tau Beta Pi's 25-year-old graduate fellowship program, the time-scheduling of elections and initiations to membership, and the Association's quarterly magazine, *The Bent*, were also approved. The national meeting will be held at Michigan State College (East Lansing) next October, with the Michigan Alpha chapter as host.

Outstanding event of the Ames convention was the initiation and banquet program on Friday, October 22. This ceremony was conducted by Tau Beta Pi's Executive Council for 33 Iowa State College and State University of Iowa students as well as for two alumni, Professor James P. McKean and Mr. Roy E. Miller. Professor McKean is on the engineering faculty of Iowa State College, and Mr. Miller is an engineer and businessman of Punxatawney, Pa.

Main speaker at the banquet was Earl O. Shreve, Tau Beta Pi member, retired vice-president of General Electric, former president of the U. S. Chamber of Commerce, and currently head of the Treasury Department's bond drive. His address was "Our Nation's Future."

A testimonial was delivered to Professor A. D. Moore of the University of Michigan, former president, councilor, director of fellowships, and alumni representative for Tau Beta Pi. The testimonial was delivered by R. C. Matthews who was Tau Beta Pi secretary-treasurer for 43 years. A gift was also presented to Professor A. D. Moore on behalf of the association by President E. R. Moore.

Valuable features of Tau Beta Pi Conventions are chapter-work discussions and exhibits. Ideas for school and community service projects and chapter administration are exchanged by the delegates. This year's discussions were led by Dr. M. E. Van Valkenburg of the University of Utah, chapter co-ordinator. Bruce L. Hill, senior civil engineering student at Iowa State, was in charge of all arrangements for the host chapter. President of the host group is John W. Stemple, and the chapter advisory board chairman is Professor Lowell O. Stewart, head of civil engineering at Iowa State. Business meetings were presided over by Lester L. Brown, student delegate from the University of California at Los Angeles.

Tau Beta Pi is a national engineering honor society founded at Lehigh University, Bethlehem, Pa., in 1885. It now has 96 undergraduate chapters in U. S. engineering colleges, 26 alumnus chapters, and more than 80,000 initiated members. Students are elected to membership by the chapters from the top 20 per cent of their engineering classes on the basis of character and school service. Alumni may be elected on the basis of their eminent achievements in the engineering profession.

Spokane Section Visits Fairchild Air Force Base

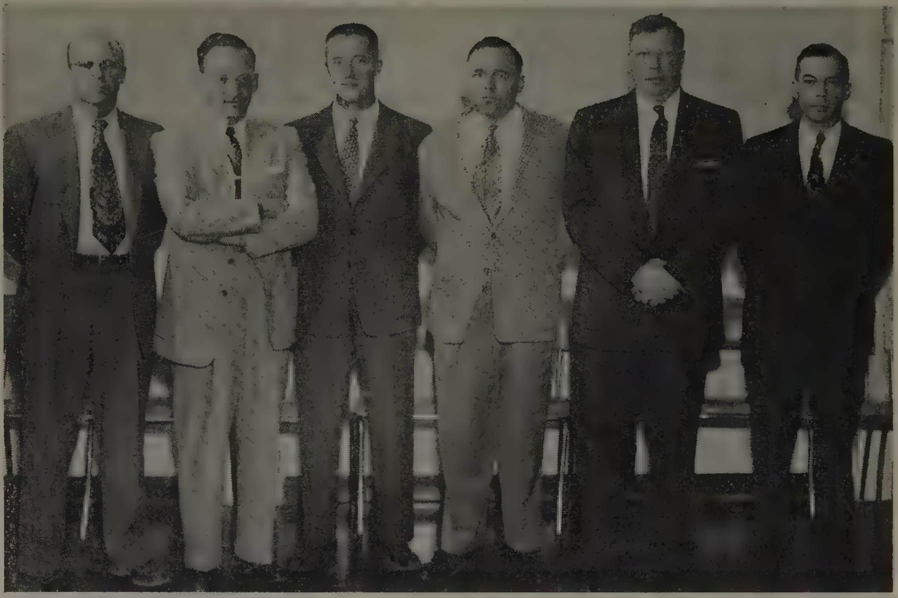
A field trip to the Fairchild Air Force Base, located a few miles west of Spokane, was sponsored last October 23 by AIEE's Spokane Section. More than 200 members and guests turned out for the visit. This included about 30 students from the University of Idaho and the State College of Washington, and a delegation from the Wenatchee Subsection. The trip covered the simulator room where members took a "trip" and "lived through" the crash of a *B-36*; the gunnery area, where they saw how the enemy is shot; as well as the Loran installation, where planes are brought in blind.

An annual get-together night is planned

with the Ladies Auxiliary. This meeting will include dinner and entertainment. Last year's meeting with the ladies was well attended.

Chairman H. C. Martindale wants to increase the Section's activities with the Student Branches at the University of Idaho and the State College of Washington this year. This is in line with the over-all national effort to promote engineering and science as career possibilities.

Los Alamos–Santa Fe Subsection Organized



The Los Alamos–Sante Fe Subsection of the Northern New Mexico Section was organized in September of this year. The Subsection's activities are well-attended, averaging 35 present per meeting. Requests for membership blanks have indicated a need for a Subsection in the area and, in addition, several AIEE members who had contemplated dropping their membership have decided not to do so because of the establishment of this group. Officers appearing in the photograph are: J. C. Pharr, membership chairman; L. M. Swenson, secretary-treasurer, Northern New Mexico Section; J. F. Cully, chairman; A. E. Embry, vice-chairman; W. B. Hills, program chairman; Owen Holtan, arrangements chairman. Not present when this photograph was taken: Secretary-Treasurer H. A. W. Hedke, Publicity Chairman H. P. Brower, and Santa Fe Arrangements Chairman Carl Albach

Annual Report Issued by Engineering Societies Library

In the Annual Report of the Director of the Library, it was stated that current interest in acquiring a new Engineering Societies Building has made the consideration of space needs important. The Library Board had already started to study space requirements when a request was received from United Engineering Trustees, Inc. (UET) to investigate the possibility of reducing the Library's requirement of 10,000 square feet in a new building. In response to this request, a committee made an extensive study and prepared a report unanimously approved by the Board, and transmitted to the UET.

Findings and conclusions presented in the report are believed to be of long-range importance to the Founder Societies, the UET, and the Library. Some main points of the report were:

1. In new quarters, specifically designed for library use, the square feet now used for the Library might be reduced.
2. Despite this possible saving, the collection of books and periodicals would have to be reduced 68 per cent if only 10,000 square feet were available.
3. The cost of microfilming 68 per cent of the collection would be prohibitive—about a million and a half dollars, in addition to which operating costs would be increased.
4. Special space-saving equipment of the drawer and hinged-shelf type is expensive, unsatisfactory, and a definite safety hazard.
5. Co-operative storage facilities for library books are available in only a few areas in the United States. Even where available, it would be impracticable to store 68 per cent of the collection at a distance from the Library.
6. If 68 per cent of the books in the present collection were to be discarded, the Library no longer would be outstanding; no longer would it be a primary source of information and service for the profession. Other engineering libraries would then surpass it in size, but none would have the collection, the organized information, and trained staff required to give service to the engineering profession equal to that now provided by the Library.
7. The committee could see no nondestructive means of housing the library in 10,000 square feet. It was estimated that up to 1980 26,000 square feet would be required.

Over-all use of the Library increased during 1953–54. Orders for bibliographies increased greatly because of the issuance of a new "Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries." The number of books borrowed dropped sharply because of the Library Board's action last year discontinuing the lending of periodicals. The Board's other action changing the hour of closing from 10 p.m. to 9 p.m. has apparently inconvenienced few members or others using the Library reading room. Some statistics follow:

	1952–53	1953–54
Visitors served	16,452	16,817
Non-visitors served	21,297	21,278
Total	37,749	38,095
Photoprint orders	4,540	4,704
Photoprints	60,243	63,506
Microfilm orders	388	295
Bibliography orders	109	586
Searches and paid services	147	127
Translations	170	161
Words translated	330,532	260,335
Borrowers	2,149	1,270
Books lent	3,179	1,640
Telephone inquires	9,882	9,349
Written replies to inquiries	4,021	4,786

Among the Library staff's other activities were: preparation of reviews of books valued at $3,700. These reviews were supplied to the four Founder Societies, the Engineering Institute of Canada, and the Engineering Index. In addition to the value of books received for review, the Library spent about $2,000 for books that were not reviewed.

J. L. Head Re-elected President of UET

James L. Head, Anaconda Copper Mining Company, was re-elected president of United Engineering Trustees, Inc. (UET) at its 51st annual meeting, October 28, 1954.

Other officers elected were vice-presidents W. J. Barrett (F '50), New Jersey Bell Telephone Company, and W. F. Thompson, Westcott and Mapes, Inc.; treasurer, W. G. Bowman, McGraw-Hill Publishing Company; assistant treasurer, J. L. Kopf, Jabez Burns and Sons, Inc.; secretary, John H. R. Arms, secretary and general manager since 1933.

The membership of the UET is 12 men, three appointed by each Founder Society to represent them in matters of mutual or combined professional and educational interests.

The Trustees control various extensive gift funds for use in engineering and scientific research, a free public engineering library, and the Engineering Societies Building headquarters. With the growth in memberships in the Founder and other engineering societies in the building, and the increase in engineering development, one of the prin-

cipal objects of UET study at present is to obtain larger quarters and to determine the location. Various cities have extended invitations to establish the engineering headquarters in their territory and the locations are being evaluated on the basis of the needs of the profession as a whole.

EJC Sets First Open Annual Meeting for January 21

For the first time in its history, Engineers Joint Council (EJC), will hold a public annual meeting and banquet. A day-long program of discussions on professional subjects will take place January 21, 1955, in the Hotel Statler, New York City. There will be addresses at luncheon and dinner by nationally known figures, and new officers will be installed in the evening.

While a broad variety of matters will be discussed by committees and speakers, the basic theme will be further activities of the Council in uniting the engineering profession. Subjects to be covered include: several aspects of the manpower shortage, employment conditions as they affect engineers, and the national water policy which has occupied the Council's attention for several years. Activities in specialized areas of engineering, such as the industrial and peacetime phases of nuclear development, and the future usefulness of EJC to affiliates and associates, will also be discussed.

Transactions of 1951 World Power Conference Available

The Transactions, covering reports and discussions of the Sectional Meeting, World Power Conference, at New Delhi, India, in 1951, in connection with the International Engineering Conference, are now available. Volumes I, II, and III may be obtained, at £9.15s per set, from the Secretary of the Indian National Committee, World Power Conference, 8 Gokhale Road, Calcutta 20, India. When ready, volume IV, the index, will be sent to purchasers of complete sets.

Six technical sessions of the Sectional Meeting of the World Power Conference were held for discussion of "Utilization of Power in its Various Aspects," under twelve subheadings of two main subjects. These main subjects were the utilization of electricity in agriculture, and the co-ordination of the development of industries and the development of power resources.

On the first subject, 19 reports were presented by representatives of eleven nations. A wide range of subjects was covered, including utilization of electricity for irrigation, the farm, the home, processing of agricultural products, and for manufacturing fertilizers. The United States reports were by C. R. Wickard on "Electricity in Agriculture" and L. N. McClellan on "Feasibility of Irrigation Projects Increased by Development of Hydro-Electric Power."

Under the second main subject, 28 reports were presented by representatives of nine countries. Various phases included power load planning, modern equipment methods, and research in power utilization; power and cottage industries; interconnection and co-ordination of power systems; design and construction of power stations and transmission facilities.

Reports from the United States were by D. L. Beeman on "Power Distribution in Light and Heavy Industries," F. R. Benedict on "Electric Power and Heavy Industries," M. W. Straus on "Water and Power in Our World," A. C. Clogher and R. P. Crippen on "Co-ordinated Utilization of Thermal and Hydro Energy Resources."

Throughout the sessions emphasis was placed on the importance of industrial development in raising the standard of living of underdeveloped countries and the need for close co-ordination between such development and the provision of necessary power supplies.

Sound and Slide Program Sponsored for Students

As part of the co-ordinated program of the Institute Committee on Student Branches for 1954–55, AIEE is sponsoring a sound and slide program for all electrical engineering students who are AIEE Branch members. This program will appear under the title, "Electrical Engineering—a Creative Profession."

The program's purpose is to better acquaint the students with the many fields of the electrical engineering profession. The initial sound and slide presentation, "Expanding Opportunities for Tomorrow's Electrical Engineers," is sponsored by the Westinghouse Electric Corporation and features Institute President A. C. Monteith. This covers, in a general way, the broad field of electrical engineering. It also serves to bring the Institute president to the Branches.

Each succeeding presentation will cover in more detail a specific branch of electrical engineering. These presentations are sponsored by various companies in much the same way as these companies would sponsor a speaker to present the subject in person. It is difficult to cover all the Branches on any one subject with speakers, and thus this sound and slide program is the most practical means for extended coverage.

Each presentation will take 15–20 minutes. Pictures are 35-mm, slides in 2-×2-inch mounts, and a standard recording tape at the $3^3/_4$-inches-per-second-speed is used. This tape recording is made by representative engineers from the sponsoring companies.

The presentations are being arranged so that they may be fitted in easily at any previously planned meeting as an opening feature, or as an extra. Many could be used as the main feature of a meeting, with a planned discussion period afterwards.

Distribution of the sound and slide presentations will be through the chairmen of the District Committees on Student Activities. Each District Committee chairman will make arrangements for showing of each presentation to the Branches in his District. Organization of this program is handled by G. W. Bower, member of the Institute Committee on Student Branches.

A new activity of the Institute Committee on Student Branches, this program provides one more service from AIEE, and should prove helpful to students in visualizing career horizons of tomorrow.

COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Power Division

Committee on Transformers (*J. A. Adams, Chairman; J. R. Meador, Vice-Chairman; M. H. Pratt, Secretary*). The work of the Committee on Transformers is divided among subcommittees, one of which is the Subcommittee on Dielectric Tests. The scope for the committee is as follows: "To determine test voltage requirements for service conditions or conversely voltage tests which will determine that service requirements are met." In order to cover this scope, there has been a subdivision into projects. Projects for this subcommittee are to be as follows:

1. Test Voltages for Transformers for Systems Above 230 Kv
This project involves the establishment of test voltages, both 60-cycle and impulse test values, for higher voltage systems. Maximum continuous operating voltage of power systems is also involved in this work.

2. Revision of Table 11.030 on Dielectric Tests
A revision of this table is being made for general improvement. It will be divided into separate tables for each type of apparatus. The table covering standard dielectric tests for oil-immersed transformers has been approved by the Transformer and Standards Committees. Other tables such as those for regulators and reactors, are under preparation.

3. Insulation Power Factor Testing of Transformers
A test code for power factor testing of power transformers was approved by the Transformer Committee and sent to the Standards Committee. It was recommended that this be published as an AIEE Standard, or, at the discretion of the Standards Committee, be published on a trial basis for one year. This test code was limited to oil-immersed units. Test codes for other transformers are under consideration.

4. Impulse, Switching, and Service Insulation Strength of Transformers
More comprehensive data are to be obtained on the impulse, switching, and 60-cycle strengths of transformer insulations.

5. Service Requirements of Transformers with regard to Switching Surges
Attempts have been made to obtain data on types and durations of switching surges to which transformers may be subjected. Also, an attempt

will be made to establish a standard switching surge, as was done in the case of lightning, for use as a basis of design. Since other apparatus and system operation are involved, suggestions of other committees are being obtained.

Committee on Substations (*I. S. Mendenhall, Chairman; W. S. Scheering, Vice-Chairman; J. A. Smith, Secretary*). In addition to the active continuation of the various projects that have been reported previously, the committee is organizing a Working Group to consider a new project, Grounding and Corrosion in Substations. This will be an extension of the work of a former group that culminated in a report, "Application Guide on Methods of Substation Grounding," presented at the 1954 Winter General Meeting. The new project will be more concerned with corrosion problems that are a part of grounding practices.

The committee has organized a West Coast Subcommittee for the purpose of promoting committee interests there, and to afford members in that area a greater opportunity to participate in the Institute's technical activities. At the present time there are 19 subcommittee members. The first meeting was held in San Francisco, October 29.

Committee on Carrier Current (*S. C. Leyland, Chairman; L. G. Eaton, Vice-Chairman (East); L. E. Ludekens, Vice-Chairman (West); H. W. Lensner, Secretary*). Subcommittee activity at the present time is being concentrated on two main subjects: methods of measurement of carrier-frequency quantities, and standards for carrier radiation. These are two long-term projects, the results of which will be of much value in the field of power-line carrier. In addition, the Microwave Subcommittee has been enlarged to expand its activity.

Science and Electronics Division

Committee on Electronics (*H. C. Steiner, Chairman; J. D. Ryder, Vice-Chairman; D. G. Wilson, Secretary*). As a result of the transfer of the Electronic Power Converter Committee to the Industry Division, the Hot Cathode Converter Subcommittee, under the chairmanship of W. H. Bixby, has been returned to the Electronics Committee. This subcommittee has recently finished the final draft of Section II of the proposed ASA Standards on hot-cathode power converters.

R. E. Higgs has resigned as chairman of the Subcommittee on Electron Tubes and D. S. Peck will serve in that capacity for the remainder of the term. The Gas Tube Group, in conjunction with the Institute of Radio Engineers' Subcommittee on Gas Tubes, has submitted definitions of terms for review and forwarding to the American Standards Association.

Under the chairmanship of H. J. White, the Subcommittee on Electrostatic Processes plans to present the results of work on rectifier standards for electrical precipitation in a session at the 1955 Winter General Meeting.

AIEE FELLOWS ELECTED..

Board of Directors Meeting, August 12, 1954

Winfred H. Stueve (M '43), consulting and mechanical engineer, Oklahoma City, Okla., has beed transferred to the grade of Fellow in the AIEE "for contributions to the use of electric power in the petroleum industry; particularly to the movement of oil and gas

W. H. Stueve

through pipe lines." Mr. Stueve was born at Wapakoneta, Ohio, August 5, 1885. He received his master of engineering degree in electrical engineering from Ohio State University, 1908; the professional master of science degree from Ohio State, 1936; and the professional master of science degree from Oklahoma Agricultural and Mechanical College in 1952. Mr. Stueve is a member of the National Society of Professional Engineers and is a registered professional engineer in Oklahoma. He was consulting engineer, municipal power plants and distribution systems, Tulsa and Muskogee, Okla., 1909–18; U. S. Navy engineer officer, Cruiser and Transport Forces, 1918; consulting electrical engineer, Muskogee, 1919–24; power consultant, executive assistant, Oklahoma Gas and Electric Company, 1925–50. During these 25 years (1925–50) as power consultant in charge of oil field electrification, many economic studies were constantly being made to convince oil operators that the use of electric power for their operations would result in lower cost than could otherwise be achieved. He built up the revenues of Oklahoma Gas and Electric Company for oil industry purposes to $3,000,000, or 15 per cent of the total revenues in 1950. He was loaned by Oklahoma Gas and Electric Company to assume supervision of engineering and design on electrical features of the following: 1928—to Shell Pipe Line Company, electrification of first all-electric pipe line, McCarney, Tex., to Cushing, Okla.; 1930—to Texas-Empire Pipe Line Company, electrification of ten 2,400-hp Booster Stations, Cushing, Okla., to Chicago, Ill.; 1930–32—to Oklahoma Pipe Line Company (Standard Oil of New Jersey), for electrification of all stations involving 18,000-hp change-over; 1942–44—to War Emergency Pipe Lines, Inc., Washington, D. C., as chief electrical engineer, handling design and negotiating power contracts for the "Big Inch" pipe lines; 1947—to United Gas, Shreveport, La., and Southwest Gas and Electric Company, as consultant in economic study and later electric motors, replacing oil pumps in former Big Inch systems; 1949—electrical engineer, Santos–Sao Paulo Pipe Line, Brazil. Since retiring from the Oklahoma Gas and Electric Company in 1950, Mr. Stueve has been a consulting engineer in the mechanical and electrical fields, specializing particularly with respect to petroleum, gas, and oil pipe lines and production. Mr. Stueve is the author of the Petroleum Power Section of the "Electrical Engineers Hand Book." He has served on the State Board of Registration for Professional Engineers in Oklahoma and is a member of The American Society of Mechanical Engineers and the American Institute of Mining and Metallurgical Engineers.

AIEE PERSONALITIES.....

H. T. Friis (AM '20, F '41), director of research in high frequency and electronics, Bell Telephone Laboratories, has been named by the Institute of Radio Engineers (IRE) as the recipient of the IRE Medal of Honor, highest technical award in the radio engineering profession. The award, which was given "for his outstanding technical contributions in the expansion of the useful spectrum of radio frequencies, and for the inspiration and leadership he has given to young engineers," will be presented during the March IRE National Convention. Dr. Friis began his career in 1916 as assistant to Professor P. O. Pedersen in Copenhagen, Denmark. For the next two years he worked as Technical Advisor at the Royal Gun Factory in Copenhagen. He received a Fellowship from the American-Scandinavian Foundation in 1919. In 1919 he joined the Western Electric Company's research department, later Bell Telephone Laboratories. His first work was on ship-to-shore radio reception. From 1921 to 1929 he took part

H. T. Friis

in pioneering theoretical studies of radio reception and then assumed direction of a group working on short-wave studies. Dr. Friis served as director of radio research from 1945 to 1952 when he was appointed director of research in high frequency and electronics. During his years of association with Bell Laboratories, Dr. Friis has made notable contributions in radio transmission, including methods of measuring signals and noise; in the creation of a receiving system for reducing selective fading and noise interference; in microwave receivers and measuring equipment; and during the war in radar work. Professional activities include membership in the American Association for the Advancement of Science; Danish Engineering Society; American Section, International Scientific Radio Union; Danish Academy of Technical Sciences; Panel for Basic Research, Research and Development Board, Washington, D. C.; and the Scientific Advisory Board, Army Air Force.

W. L. Cisler (M '35, F '47), president of The Detroit Edison Company, has been named to receive the ASME George Westinghouse Gold Medal Award at the ASME Annual Meeting in New York, November 29–December 3. The award, which is administered by the Board on Honors of The American Society of Mechanical Engineers, is given, when warranted, for eminent achievement or distinguished service in the power field of mechanical engineering, including contributions in the utilization, application, design, development, research, and organization and administration of power facilities. Mr. Cisler earned a master of engineering degree at Cornell University. He joined the staff of Public Service Electric and Gas Company, Newark, N. J., following his graduation. Before the beginning of World War II, his company loaned Mr. Cisler to the War Production Board, Office of War Utilities, to assist in mobilizing electric power for the preparedness program, and later to develop and supervise the schedules and production of all power equipment, including that for the Army and Navy Departments. He also developed and allocated equipment for Lend-Lease. Mr. Cisler was employed by Detroit Edison in 1943 and granted a leave of absence to serve in the U. S. Army at the request of the Secretary of War. Commissioned a lieutenant colonel, he was assigned to the Mediterranean Theatre to make recommendations concerning rehabilitation and operation of electric power facilities. In 1944, Mr. Cisler was appointed chief of public utilities on General Eisenhower's SHAEF staff, in which position he supervised restoration of electric power, gas, and water service for civilian and military use. Following the dissolution of SHAEF in 1945, Mr. Cisler, then a full colonel, became chief of the Public Utilities Section, Office of Military Government for Germany. For his service during the war, he was awarded the American Bronze Star, the American Legion of Merit, the French Croix de Guerre with Palm, the French Legion of Honor, the English Order of The British Empire, the Netherlands Order of Orange Nassau, the Belgian L'Ordre de Leopold, and the Stella della Solidarieta Italiana. Mr. Cisler returned to Detroit Edison following his military retirement, and became chief engineer of power plants at a time of intensive power expansion work in his firm. He has worked on the following AIEE committees: Power Generation (1935–41, Chairman 1940–42, 1943); Technical Program (1940–42); Standards (1941–42); Management (1947-49, Chairman 1948–49, 1950–54); Professional Group Coordinating (1948–49).

E. B. Powell (AM '01, M '13, Member for Life), consulting engineer with Stone and Webster Engineering Corporation, Boston, Mass., has been named to receive The American Society of Mechanical Engineers' (ASME) Medal. The award, which is administered by the Board on Honors of the ASME, is presented annually for distinguished service in engineering and science, and will be conferred on Mr. Powell at the ASME's annual meeting in New York, November 29–December 3. The citation accompanying the medal praises Mr. Powell "for his thorough knowledge and accuracy in solving many difficult scientific and engineering problems of steam power generation, and for his outstanding leadership in the development of designs incorporating advances for boiler furnaces and water treating equipment. . ." Born in Brook Haven, Miss., in 1880, Mr. Powell was educated in Millsaps College, Jackson, Miss. Following his graduation he began work with New York Edison Company, as supervisor of the chemical laboratory and mechanical testing department. In 1907 he joined Stone & Webster and introduced systematized methods of operation and maintenance in a large number of power and construction companies then under the management of his firm. It was at this time that he designed and placed in operation the first pulverized coal burners installed in any American public utility. Since 1920 Mr. Powell has been a consultant engineer with Stone & Webster. His work has involved research and investigations of equipment and materials in every phase of power generation. He is the author of many papers on power generation, and is a member of the American Society for Testing Materials, as well as AIEE.

H. E. Ellithorn (AM '40, M '47), associate professor of electrical engineering, University of Notre Dame, Notre Dame, Ind., has been appointed head of the department. A specialist in network theory, Professor Ellithorn is a native of Detroit. He attended Union College, Schenectady, N. Y., and later received his master's degree from Harvard. Dr. Ellithorn has been with Notre Dame since 1940. In 1945 he obtained a Ph.D. in physics from the university. Prior to joining the Notre Dame faculty he had been director of the engineering laboratory, Sylvania Electric Company, Salem, Mass. Besides AIEE, he is a member of the Institute of Radio Engineers, the American Association of Engineering Educators and the American Institute of Physics, as well as Sigma Xi, honorary research society. He is a past president of the Notre Dame Lay Faculty Club. Dr. Ellithorn's AIEE committee work has been with the Communication Committee (1944–46, 1948–49); and with the Wire Communications Systems Committee (1949–54).

H. M. Towne (AM '24), sales manager, Lightning Arrester and Cutout Division, General Electric Company, Pittsfield, Mass., retired October 1, after completing 45 years of continuous service with the company. He may later engage in consulting service for insurance, architectural, and engineering firms on unusual problems of lightning protection of structures or power systems. Mr. Towne, a native of Williamstown, Mass., began his career in the factory organization on the assembly line at the Pittsfield, Mass., plant. His first four years with the company were devoted to routine and developmental test work; and in 1913 he became foreman of the lightning arrester test where he did some of the earliest work in Pittsfield on the design and use of impulse generators for high-voltage testing. Four years later he joined the lightning arrester engineering department where he specialized in design and application problems. In 1928 he went to Japan for a 7-month assignment on promotional and field engineering work. In 1929 he entered the Sales Division where he supervised the sale of lightning arrester equipment, and traveled extensively to promote new concepts for improved protection of power systems resulting from General Electric's laboratory and field researches. He became manager of sales of the lightning arrester and cutout business in 1942, the position he held at the time of his retirement. Besides AIEE, he is a member of the Association of American Railroads Signal Section.

J. F. Calvert (AM '27, F '45), professor and chairman of the Department of Electrical Engineering at Northwestern University, has been named professor and head of the Electrical Engineering Department at the University of Pittsburgh. Dr. Calvert has already assumed his new post. He has been professor of electrical engineering at Northwestern since 1938 and has served as chairman of the department since 1939. He was formerly associate professor in electrical engineering at Iowa State College from 1936–38. From 1925 to 1936, he was associated with the Westinghouse Electric and Manufacturing Company. During this time he took part in the Westinghouse program at the University of Pittsburgh, serving as a graduate lecturer. Dr. Calvert is a graduate of the University of Missouri where he received the bachelor of science degree in electrical engineering. He later attended the University of Pittsburgh where he received the master of science degree in 1930 and the doctor of philosophy degree in mathematics in 1936. From 1941–42 he was on loan from Northwestern for special duties with the United States Naval Ordnance Laboratory and has since served on various other armed services research projects. He is a member of the Western Society of Engineers, American Society for Engineering Education, American Association for the Advancement of Science, American Association of University Professors, Institute of Radio Engineers, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi, professional societies. His AIEE committee service includes: Electrical Machinery (1939–47); Student Branches (Chairman 1946–48, 1949); Air Transportation (1946–47); Membership (1947–48); Edison Medal (1950–55, Chairman 1952–53); Professional Division Advisory (1951–52); Washington Award Commission (1952–54); Computing Devices (1953–54).

C. C. Shackford (AM '36), assistant chief engineer, Electrical Wire Division, John A. Roebling's Sons Company, has been named product engineer of the division, the firm's top electrical engineering post. Mr. Shackford joined the Roebling Corporation in 1935 as a student engineer in the Electrical Wire Division, following his graduation from Lehigh University where he received a B.S. degree in electrical engineering. During World War II, Mr. Shackford served five years with the United States Navy, assigned primarily to projects relating to electronics instruction, research and development, and radar installation and use aboard ship. His tour of duty included service as electronics officer on the battle cruiser *USS Guam.*

R. F. Cline (AM '37, M '44), project engineer, Parson Aerojet Company, Los Angeles, Calif., has been appointed chief engineer, Electronics Division, Mullenbach Electrical Manufacturing Company, Los Angeles, Calif., to direct the development of Mullenbach's new Capaswitch.* Mr. Cline graduated in 1936 from the University of Toronto with a bachelor of applied science degree in electrical engineering, and then spent nine years as research and development engineer in the electric furnace plant of Norton Abrasive Company in Niagara Falls. In 1946 he obtained his master's degree in electrical engineering from California Institute of Technology. This same year he joined the staff of Bechtel Corporation in Los Angeles, and was in charge of the Synchronous Motor Division for Southern California Edison's frequency change project. Next Mr. Cline became chief electrical engineer, Industrial Division, Ralph M. Parsons Company. Subsequently, he was associated with Electric Machinery Manufacturing Company as sales engineer.

Joel Tompkins (AM '30, M '48), chief of the Electrical Division of Alcoa's Aluminum Research Laboratories at Massena, N. Y., has been transferred to the central electrical engineering department at Pittsburgh, Pa. **H. E. House** (AM '30, M'45), senior staff engineer of the Power Division at the company's works in Alcoa, Tenn., has succeeded Mr. Tompkins in the Massena post. Mr. Tompkins has been active on AIEE's Electronic Power Converters Committee (1947, 1949), and Chemical, Electrochemical, and Electrothermal Applications (1947, 1949–51).

R. C. Setterstrom (AM '30, M '41), industrial engineer for The Montana Power Company in Butte, Mont., has been elected president of the Northwest Electric Light and Power Association, covering Oregon, Washington, Idaho, Montana, Utah, and British Columbia. The Association promotes interchange of ideas to provide top quality electric service for member companies. Mr. Setterstrom was born June 1, 1905, at Little Falls, Minn. He is a graduate of Oregon State College in Corvallis, from which he has a bachelor of science degree in electrical engineering, granted in 1928. From 1928 to 1940 he was with the Westinghouse Electric Corporation, most of the time as sales engineer in Seattle, Wash., and in Butte. Since 1940 he has been with The Montana Power Company in Butte as industrial development engineer. He was on the AIEE Membership Committee (1942–44) and Industrial Power Systems Committee (1948–49).

W. H. Henrich (AM '47), chief development engineer for Sorensen and Company, Inc., Stamford, Conn., has been named assistant to the general manager in charge of production and sales of the Condenser Products Company, Division of New Haven Clock and Watch Company, New Haven, Conn. Previously he was employed as electronics engineer by the Laboratory of Advanced Research, Remington Rand, Inc., South Norwalk, Conn. He has been a lecturer in physics at the University of Bridgeport, Conn., and holds patents on electronic-controlled high-speed printing mechanisms and voltage regulators.

J. J. Doran (AM '47), senior utilities engineer in the research section of the Utilities Division of the California Public Utilities Commission, has been promoted to electrical engineer in charge of the electric section. He is a University of Santa Clara graduate, who has been with the Commission since 1947.

Rudolf Feldt (M '46), manager, Cathode Ray Instrument Division, Allen B. DuMont Laboratories, Inc., Clifton, N. J., is now manager of the new Instrument Division organized by the Federal Telephone and Radio Company, Clifton, N. J., a division of International Telephone and Telegraph Corporation. The new division is for manufacture and distribution of measuring and testing instruments and will make available to the American market products of domestic and foreign manufacturing associates of the worldwide IT and T system, as well as other instrument makers abroad. Prior to his being manager of DuMont's Cathode Ray Instrument Division, he was with IT and T System associates in Germany and France. He has served on the AIEE Electronics Committee (1947–54), and the Instruments and Measurements Committee (1950–54). He is chairman of the Group Subcommittee on Electronic and High-Frequency Instruments of this latter committee.

G. W. Brown (AM '52), executive engineer of Wagner Electric Corporation, St. Louis, Mo., has been elected a vice-president by the company's board of directors. In his new capacity Mr. Brown will have complete charge of Wagner's Engineering and Research Divisions, both automotive and electrical, and will also serve as a member of the company's executive committee. Mr. Brown, a graduate of Ohio State University, joined the Wagner company in 1926, and for ten years worked in the electrical engineering department where he specialized in the development, design, and application of fractional-horsepower motors. In 1937 he was appointed to the newly established position of personnel director. In 1945, after serving three years as an officer with the U. S. Army Ordnance Department in the Office, Chief of Ordnance, he returned to the company to become industrial relations director. In 1952 he returned to engineering as the company's executive engineer, with responsibility for the general executive direction of automotive and electrical engineering and the metallurgical and chemical departments. He will continue this work on a broader scale as vice-president.

W. C. Hall, (M '46), superintendent of the Solid State Division, Naval Research Laboratory, has been named associate director of research for nucleonics. A native of Reading, Kan., Dr. Hall is a graduate of the University of Kansas, having received his degree of Doctor of Philosophy in physics from that college in 1936. From 1931 to 1935, Dr. Hall was an instructor in physics at the university. He joined the Naval Research Laboratory in 1935, where his major field of research activity was in thermal conductivities. In 1947, Dr. Hall was named the first superintendent of the new Electricity Division. In March, 1954, he was selected as the first superintendent of the Solid State Division. He was on AIEE's Basic Sciences Committee (1948–50).

Alfred Malkin (AM '44, M '51), assistant to construction engineer, Canadian Car and Foundry Company, Ltd., has been appointed electrical engineer with the firm of Stadler, Hurter and Company, consulting engineers. Mr. Malkin was born in England and served with the Canadian Forces overseas during World War I. Following seven years with the Northern Electric Company in their power switchboard engineering department, he joined the architectural firm of Ross and MacDonald. During depression years he was employed by various consulting engineers and by Canadian Industries, Ltd., and the Canadian Broadcasting Corporation. Joining Canadian Car Munitions in 1940, he was responsible for the electrical layout of the plant in co-operation with representatives of the British Government. He was later transferred to the head office of the Canadian Car and Foundry Company, Ltd., where he remained until his recent resignation as the company's electrical engineer.

OBITUARIES • • • • •

Archibald Hunt Davis, Jr. (AM '17, M '19), electrical engineer, Wright Air Development Center, Wright-Patterson Air Force Base, Dayton, Ohio, died September 10, 1954. Mr. Davis was born in Elyria, Ohio, July 13, 1890, and was graduated from the Georgia Institute of Technology in 1910. He entered the General Electric test course at Schenectady, N. Y., in 1910, and was given assignments in the laboratory of Dr. Steinmetz until entering the United States Navy in 1917. During 1917–18 he served as a lieutenant in the Bureau of Steam Engineer-

* Reg. trade-mark of Mullenbach Electrical Manufacturing Company.

ing and lectured at the United States Naval Academy, Annapolis, Md. Following the war he became chief power engineer, National Aniline and Chemical Company, Buffalo, N. Y. In 1928 Mr. Davis moved to Pittsburgh, Pa., to become vice-president in charge of engineering for the Shaw-Perkins Manufacturing Company. Ten years later he returned to the National Aniline and Chemical Company and in 1939 he became director of research and development for American Machine and Metals, Inc., East Moline, Ill. In 1943 he joined the Apex Electric and Manufacturing Company of Cleveland and Sandusky, Ohio, with the same title. He held this position until shortly before his death when he accepted the assignment with the Air Force. Mr. Davis held many patents in electrical and mechanical fields and was a registered professional engineer in several states.

Alvah R. Small (M '37, F '43), retired, Pompano, Fla., and former president and vice-chairman, Underwriters' Laboratories, Inc., Chicago, Ill., died October 8, 1954. Born in South Portland, Maine, December 7, 1882, Mr. Small received a bachelor of science degree in civil engineering from the University of Maine in 1904 and a degree of civil engineering from the university in 1929. Following his graduation in 1904 he joined the staff of the New York Fire Insurance Exchange, New York, N. Y. In 1906 he became an assistant electrical engineer with the Underwriters' Laboratories, Inc., Chicago, and in 1910 he formed the label service department for the factory follow-up inspection of listed products. Mr. Small was promoted to vice-president in 1916 and in 1924 was transferred to the Laboratories' office in New York. In 1935 he returned to the main office and testing station in Chicago as president of the Underwriters' Laboratories. He retired from active service in 1948 with the title of vice-chairman. A past president of the National Fire Protection Association and active on many of its committees, he was president of the organization's Electrical Committee which is responsible for the National Electrical Code. He was a member of the Advisory Engineering Council of the National Board of Fire Underwriters, American Standards Association, the American Society for Testing Materials, and the International Association of Electrical Inspectors. Mr. Small served on the AIEE Committee on Safety (1937–39).

Thomas Clair McFarland (AM '22, M '32, F '45), professor of electrical engineering, University of California, Berkeley, died September 16, 1954. Professor McFarland was born in Porterville, Calif., on July 19, 1893. He was graduated from the University of California in 1916 and received his masters degree in 1923. From 1916 to 1918 he was with the General Electric Company, Schenectady, N. Y., as a student engineer, and from 1918 to 1919 he served in the United States Naval Reserve. Joining the University of California faculty in 1920 as an instructor, he became assistant professor in 1925, associate professor in 1931, and full professor in 1946. He held the chairmanship of the Division of Electrical Engineering from 1943 to 1953. Professor McFarland wrote a textbook on electrical engineering now in use at the university. He was a consultant in the establishment of electric voting equipment in California and adviser to the Bell Telephone Company on the installation of submarine telephone equipment for the Navy. He was a member of Eta Kappa Nu, Tau Beta Pi, Sigma Xi, and the American Association for the Advancement of Science. Professor McFarland served on the AIEE Committee on Education (1947–49, 1951–54).

LeRoy L. Newman (AM '07, M '36, Member for Life), electrical research consultant, New Orleans (La.) Public Service, Inc., died June 3, 1954. Mr. Newman was born in Magazine, Ark., May 29, 1874, and was graduated from the University of Arkansas in 1901. Following his graduation he joined the Memphis (Tenn.) Power and Light Company where he remained until 1903 when he became affiliated with the Pennsylvania Railroad for whom he designed small generating plants, distribution, lighting, and power for railroad yards, shops, and stations in Altoona, Pa.; Washington, D. C.; New York, N. Y.; Sunnyside, N. Y.; and Pittsburgh, Pa. In 1914 he transferred to the Birmingham (Ala.) Electric Company as chief engineer. He joined New Orleans Public Service in 1923 as superintendent of the Electric Distribution Division, a position he held until 1952 when he was named electrical research consultant. Mr. Newman was a member of the Edison Electric Institute and the Louisiana Engineering Society.

Deany C. LaZan (AM '27), Cleveland Heights, Ohio, died recently. Miss LaZan was born on August 16, 1889, in San Francisco, Calif., and attended the University of California. From 1920 to 1923 she was engaged in theatrical stage lighting and electrical work. In 1924 she joined the Simplex Wire and Cable Company factory in Cambridge, Mass., and in 1925 she was transferred to the executive and sales offices of the company in Boston, Mass. In 1926 she became assistant manager of the Simplex Wire and Cable Company's Cleveland, Ohio, branch. She remained with that office for the rest of her professional life, until 1949. Miss LaZan took an active interest in the affairs of the AIEE Cleveland Section.

MEMBERSHIP ...

Applications for Election

Applications for admission or re-election to Institute membership, in the grade of Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before December 25, 1954, or February 25, 1955, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Member

Appleby, J. H., La Electricidad de Caracas, Caracas, Venezuela, S. A.
Campbell, W. B., Federal Communications Commission, Washington, D.C.
Lomas, A. E., Automatic Electric Company, Chicago, Ill.
Narter, A. N., American Bureau of Shipping, New Yor N.Y.
Rex, C. H., General Electric Company, West Lyn Mass.
St. Clair, H. V., Carthage Machine Co., Carthage, N.
Sutton, C. T. W., Enfield Cables Ltd., Brimsdow Middlesex, England
Tucker, J. H. L., Parolle Electrical Plant Co. Ltd., New castle Upon Tyne, England

8 to grade of Member

Recommended for Transfer

The Board of Examiners at its meeting of October 2 1954, recommended the following members for transf to the grade of membership indicated. Any objectio to these transfers should be filed at once with the Secre tary of the Institute. A statement of valid reasons f such objections must be furnished and will be treated confidential.

To Grade of Member

Alspach, P. H., mfgr. development mgr., General Elec tric Co., Schenectady, N.Y.
Bachtel, W. C., design engr., General Electric Co Schenectady, N.Y.
Barr, H. V., div. mgr., Tidd Generating Station, Oh Power Co., Brilliant, Ohio
Boyd, J. A., asst. prof. of elec. engg., University Michigan, Ann Arbor, Mich.
Brown, J. D., proposition engr., General Electric Co Lynn, Mass.
Byrne, E. J., elec. engr., Barrett Div., Allied Chemical Dye Corp., New York, N.Y.
Cairone, A. R., consulting & application engr., Westing house Elec. Corp., New York, N.Y.
Christlieb I. A., mgr., Sociedad Electro-Mecanica S.A., Mexico, D.F.
Courte, F. E., div. plant engr., Southwestern Bell Te Co., Fort Worth, Tex.
Dea, D. Y. F., member of technical staff, Hughes Ai craft Co., Culver City, Calif.
Elrod, J. L., mgr. marketing, distribution transf. dept General Electric Co., Pittsfield, Mass.
Eskin, H., consulting & application engr., Westinghous Electric Corp., Buffalo, N.Y.
Fink, R. C., electrical engineer, Water & Power Dept City of Los Angeles, Calif.
Fitzpatrick, F. R., relay specialist, Westinghouse Electr Corp., Newark, N.J.
Flores, M. V., president, Servicio Electrico, S.A Mexico, D.F.
Hafstrom, J. R., systems techniques mgr., electronic centre, General Electric Co., Ithaca, N.Y.
Helm, M. S., professor of elec. engg., University Illinois, Urbana, Ill.
Henson, R. J., engg. supervisor, General Electric Co Philadelphia, Pa.
Johnson, R. W., senior staff engr., plant engg. dept Corning Glass Works, Corning, N.Y.
Jontz, W. M., relay & carrier engr., Arkansas-Missou Power Co., Blytheville, Ark.
Kaldenberg, W. G., elec. engr., Power-Plant Engg. Div Iowa Power & Light Co., Des Moines, Iowa
Keller, C. L., supt. underground dept., The Toled Edison Co., Toledo, Ohio
Kravetz, R., elec. engr., David Taylor Model Basin Washington, D.C.
Krings, F. C., application engr., General Electric Co Schenectady, N.Y.
Kussmaul, E. E., president, Kelek Co., Norwood, Mass
Lawrence, R. E., Jr., plant extensions engr., Carolin Tel. & Tel. Co., Tarboro, N.C.
Maxwell, B. M., engr., Tennessee Valley Authority Knoxville, Tenn.
Meyer, J. H., overhead design engr., Memphis Light Gas & Water Div., City of Memphis, Tenn.
Meyers, N. H., sales engr., General Electric Co., Spo kane, Wash.
Mulhern, G. M., engr., Electricity Supply Board, Dub lin, Ireland
Newman, Albert, chief engr., Homelite Corp., Por Chester, N.Y.
Parker, H. W., div. mgr., International Testing Service Div. of Jackson & Church Co., Saginaw, Mich.
Paskevich, A. F., chief elec. engr., Solvay Process Div. Allied Chemical & Dye Corp., Syracuse, N.Y.
Petruska, J. J., elec. engr., Newport Industries, Inc Pensacola, Fla.
Pharis, J. H., Jr., mgr., apparatus sales, General Electri Co., Roanoke, Va.
Price, C. D., Jr., application engr., General Electric Co Schenectady, N.Y.
Riley, R. N., engr., Westinghouse Elec. Corp., Friend ship Intl. Airport, Baltimore, Md.
Ringstrand, R. C., engr., Northwestern Bell Tel. Co Des Moines, Iowa
Rockwell, O. M., elec. engr., Palmer & Baker, Inc Mobile, Ala.
Scoville, C. J., supt., elec. maint. & constr., Portlan General Elec. Co., Portland, Oreg.
Surber, W. H., Jr., assoc. prof. of elec. engg., Princeto Univ., Princeton, N.J.
Tuttle, E. J., planning engr., Oklahoma Gas & Ele Co., Oklahoma City, Okla.
Utlaut, W. F., electronic engr., National Bureau Standards, Boulder, Colo.
Wallfred, J. E., bldg. & eqpt. engr., Northwestern Be Tel. Co., Des Moines, Iowa
Were, A. E., design engr., General Electric Co., Phil delphia, Pa.

45 to grade of Member

Thomas Alva Edison Foundation Institute Proposes Scientific Training Program

A program of co-ordinated action by educators, engineering and scientific societies, and industry directed at improving secondary education in science and technology was enunciated recently at the fifth annual Thomas Alva Edison Foundation Institute, which was held under joint auspices of the Foundation, the Engineering Manpower Commission of Engineers Joint Council, and the Scientific Manpower Commission.

Viewing the problem of bringing into line the quality and quantity of scientific training of the nation's youth with the rapidly mounting demand for competent personnel, the assembled group of some 70 educators, engineering and scientific leaders, and industrialists urged that all 3 groups must co-operate in forging a vital tool in today's "technological cold war."

Among the means proposed to achieve the objective, as expressed in a report adopted by the entire conference, were intensive efforts to communicate the need for both highly trained teachers and students well prepared to take their places in technology. Such spreading of the gospel of scientific preparedness, it was suggested, should be undertaken at all levels from industry, government, and scientific societies, down to the local levels in individual communities. Designation of some central agency to promote such a program was regarded as of paramount importance in upgrading the present level of instruction, and attracting more students into both teacher-training and into scientific pursuits.

Other elements in the report urged that steps be taken to increase the prestige of science teachers at the secondary school level; accord them more definite professional standing; set higher salaries for teachers in general, possibly with special recognition of the worth of advanced training and degrees.

It also was suggested that more use might be made of such visual aids as motion pictures and television in the field of science education as a means of improving teacher effectiveness and stimulating student interest. Other procedures advocated in the combined thinking of the group included more and larger scholarships and prizes; expansion of vocational guidance facilities and activities; and close study of the curriculum to insure proper emphasis on needs for education in science.

Future Meetings of Other Societies

American Society of Mechanical Engineers. Annual Meeting. November 28–December 3, 1954, Statler Hotel, New York, N. Y.

American Society of Refrigerating Engineers. 50th Annual Meeting. November 28–December 1, 1954, Ben Franklin Hotel, Philadelphia, Pa.

1st International Automation Exposition. November 29–December 2, 1954. 242d Coast Artillery Armory, New York, N. Y.

21st National Exposition of Power and Mechanical Engineering. December 2–7, 1954, Philadelphia, Pa.

Signal Corps Engineering Laboratories—Wire and Cable Industry. 3rd Annual Wire and Cable Symposium. December 7–9, 1954, Berkeley Carteret Hotel, Asbury Park, N. J.

American Management Association. General Management Conference. January 24–27, 1955, Statler Hotel, Los Angeles, Calif.

American Society of Heating and Ventilating Engineers. 61st Annual Meeting. January 24–28, 1955, Philadelphia, Pa.

Radar Height-Finder Developed to Detect High-Flying Aircraft

A powerful new radar height-finder being made by the General Electric Company in Syracuse, N.Y., for the U.S. Air Force is helping to strengthen defense networks of the United States and its allies.

The engineers say the radar's energy, concentrated in a narrow beam like that of a searchlight, detects planes three times as far as previous units of this type; exact range is classified. The radio energy transmitted by the radar is so powerful that it can light fluorescent lamps over 100 feet away, and can ignite flashbulbs tossed into the air immediately in front of the antenna.

It is being used together with search radar to provide information on distance, altitude, and flight direction of high-flying aircraft.

General Electric is making the new radar in mobile and fixed versions. It has already supplied a large quantity for use in strengthening the radar fences guarding the North American continent, and for defense posts in countries receiving aid from the United States under the Mutual Defense Assistance Pact. Additional units are being produced for similar use.

Huge antenna used with new radar height-finder needs a room all its own above the control center in the radome building erected in Arctic climates. Air pressure supports the rubberized glass fabric radome "balloon." Entrance to the radome is through an air lock chamber

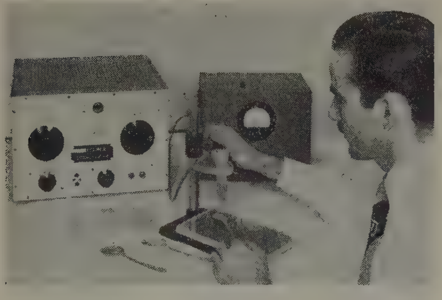
Height-finder and search radars work as a team. Data are fed from the radars to this control center in the radome building and are then relayed to fighter bases

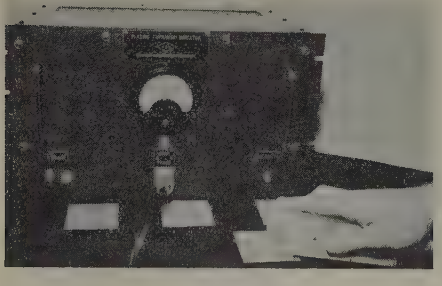
In Arctic climates, the radar is housed in a dome-shaped circular structure with a balloon-like radome made of woven glass fabric, impregnated with a rubber compound. The radome is supported by air pressure, about a half pound per square inch, and can withstand winds up to 125 miles per hour. The radome protects the radar antenna from Arctic gales, snow, and ice.

Engineers of General Electric's heavy military electronic equipment department, and the Griffiss Air Force Base at Rome, N. Y., collaborated in developing the radar.

Three Electronic Thickness Gauges Used for Metallic Coatings

Three types of instruments for measuring the thickness of electrodeposited coatings have recently been developed by the National Bureau of Standards (NBS). While all three instruments depend upon the difference in electric conductivity between the plating and the basis metal, each makes use of different methods for sensing specimen resistance. Two of the instruments, the "Dermitron" and the phase-angle thickness meter, utilize electromagnetic coupling to the specimen, making use of the reflected field from eddy currents induced in the specimen. A third, a waveguide inspection tool, employs direct conductivity measurement with point electrodes. All three devices permit simple nondestructive determination of plating thickness of sample thickness for homogeneous metals. When appropriately calibrated, they can be used for measurement of magnetic as well as nonmagnetic materials.





(Top). The Electronic Thickness Gauge, the "Dermitron," provides a particularly convenient means for measuring the thickness of plated coatings on silverware. (Center). The Phase-Angle Thickness Meter features insensitivity to variations in the probe-to-sample spacing in determining the thickness of silver plating on a nonmagnetic metal. (Bottom). The Waveguide plating indicator uses conductance measuring techniques to determine the thickness of the internal plating.

The Dermitron senses the reflected flux in a single coil which is excited with high-frequency current when it is in close proximity to the specimen. The probe coil is very small and is designed to be held in physical contact with the sample. Its miniature size makes it possible to measure plating thicknesses of small specimens and sharply-curved surfaces. When the instrument is calibrated for the specific use, measurements can be made on combinations of metals regardless of whether either coating or basis metal is magnetic or nonmagnetic. The instrument is portable and direct reading and should provide a convenient means for routine testing of a manufacturer's output.

The phase-angle thickness meter relies on the measurement of reflected electromagnetic field with a separate pickup coil. For this it requires a somewhat more complicated electronic circuit. Through a bucking transformer arrangement, a voltage is derived whose phase shift is a direct function of the specimen conductivity. Measurement of phase change thus provides a means to indicate plating thickness. Originally developed for the rapid, continuous measurement of the thickness of silver plating on such large areas as stainless-steel waveguides, it offers insensitivity to variation in probe-to-sample spacing. With suitable calibration, the instrument can also be used on magnetic materials, but probe-to-sample spacing must be controlled.

The Waveguide Plating Quantity Indicator was developed to permit measurement on both nonmagnetic and magnetic materials without change of calibration. The specific application was for use on waveguides having an intermediate layer of nickel of unknown thickness between the silver and stainless steel. In the instrument, direct current is passed through the specimen, and the voltage drop across a known distance is measured. While the silver plating is on the inside of the waveguide, its effect on the d-c conductivity measurement is the same as for outside plating. Thus the probe electrodes can be arranged to make contact on the outer surface, simplifying the measurement procedure.

A large part of the metal products manufactured in this country are clad or coated with another, usually more expensive metal to obtain special surface properties such as corrosion resistance, wear resistance, or improved appearance. For process control and inspection of the finished product, rapid, reliable procedures for measuring the thickness of the metallic coatings are required. While a great number of methods, based on almost every property of metals, have been developed for this purpose, few of these are nondestructive and direct-reading. Magnetic gauges, such as the NBS-developed Magne-gauge, are used most widely, but they are limited to combinations in which at least one of the metals is ferromagnetic. Beta-ray and X-ray thickness gauges are capable of fairly general application, but their high cost makes them suitable only for large plants having considerable volume or production. The beta-ray gauge also has the disadvantage that its use is limited to large objects. The demand for a nondestructive test method which could be made with a portable economical instrument led to the development of the three NBS gauges, each designed for a specific application.

National Science Foundation Makes 216 Grants in Support of Science

The National Science Foundation has announced 216 grants totaling about $2,650,000 for support of basic research in the natural sciences, for conferences and studies on science, for scientific information exchange, for scientific manpower, and for travel of American scientists to international scientific meetings.

This is the first group of awards to be made during fiscal year 1955 by the Foundation for the support of basic research and related matters. Since the beginning of the program in 1951, over 1,100 such awards have been made, totaling about $11,141,000. In addition, the first grant totaling $100,000, was made under a special appropriation for the International Geophysical Year.

The research fields included are astronomy, chemistry, developmental biology, earth sciences, engineering sciences, environmental biology, genetic biology, mathematical sciences, molecular biology, physics, psychobiology, regulatory biology, and systematic biology.

Steam-Electric Generating Unit Added to AGE Power System

Plans for further expansion of the American Gas and Electric Company (AGE) system by the construction of a 225,000-kw steam-electric generating unit were announced recently.

The new unit, to be built at an estimated cost of $26,400,000, will be an addition to the Glen Lyn Plant of the Appalachian Electric Power Company, an AGE operating company subsidiary. The plant is located on the New River at Glen Lyn, Va., in the western Virginia panhandle.

The unit will be the sixth of a series of 215,000-kw or slightly larger machines on the 7-state AGE system. Four of these units, the only high-pressure units of this capacity operating anywhere in the world today, have been placed in service on the AGE system in the past 15 months; the fifth such unit, now nearing completion, is scheduled for operation in about 2 months.

The new unit will burn an additional 600,000 tons of coal per year, all of which will come from producers in the Glen Lyn area. Construction is expected to start this fall and to be completed in late 1956. The new unit will more than double Glen Lyn's present generating capability, raising it to 395,000 kw. Now ranking ninth in size among the AGE system's power stations, Glen Lyn will rank sixth following the expansion.

Total generating capability of the entire AGE system will be boosted to 4,330,000 kw with the completion of the new unit. Of

this amount, 2,710,000 kw will have been added since World War II in an unprecedented expansion program which has kept pace one step ahead of the continuing growth and development of the territory served by the system.

The new unit will operate at a steam pressure of 2,000 pounds per square inch and at a steam temperature of 1,050 F. It is expected to produce a kilowatt-hour of electric energy from about 7/10 of a pound of coal.

Clarence Decatur Howe Awarded 1954 Guggenheim Medal

The Right Honorable Clarence Decatur Howe, Minister of Trade and Commerce and Minister of Defense Production of the Dominion of Canada, has been awarded the Daniel Guggenheim Medal for 1954. Mr. Howe was cited "for initiating and organizing commercial air routes and services, promoting aeronautical research, development and production of aircraft and engines, and advancing the art of aeronautics."

Research Reports Made Available by U.S. Department of Commerce

Manufacturers and research laboratories are urged to make more use of the growing stockpile of research reports released by the Office of Technical Services (OTS) of the U. S. Department of Commerce.

The Government is conducting or sponsoring scientific and technical research at a current rate of more than $2 billion a year, mostly for defense purposes. By far the largest share represents applied research and development. This research generates a vast amount of nonconfidential technical information that is available to businessmen who are interested in developing new production processes, in making technological improvements, and in avoiding duplication of research efforts. Even ideas for new products have been sparked by these reports.

Some 350 such reports are described each month in *U. S. Government Research Reports*, which is available from the U. S. Department of Commerce or any of its field offices at $6 a year.

The research covers nearly every field of industrial activity, including chemicals, plastics, paints, electric machinery and electronics, foods, fuel and lubricants, instrumentation, leather, lumber, metals, minerals, paper, ordnance, physics, rubber, textiles, aeronautics, transportation, water supply, and other items.

New Automatic Electric Cable Inspector Developed

A new cable-inspector device using an automatic electric-wiring inspection system based on continuous-scanning circuitry has been developed by Panascan, Division of Panellit, Inc., Skokie, Ill.

Cable inspector being used to check insulation resistance of multiconductor cables installed in a control cubicle

One of the unique features provided to construction and maintenance technicians by this device is automatic megging. Conductors are scanned at the rate of 1 per second. The standard unit is capable of checking insulation resistances to 110 megohms at 350 volts direct current. Higher resistance limits and test voltages can be furnished if required. This sensitivity is achieved by an electronic leakage detector.

The inspector device can automatically identify individual wires in multiconductor cables, conduit, wireways, and terminal boxes in about 1/12,500 the time required by slow manual methods. On a group of 100 wires, 10,000 tests of interconductor insulation resistance and insulation resistance to ground are performed in 200 seconds.

This equipment is designed for original test and maintenance of control cables, transmission lines, instrument and control panels, feeder and branch circuits, thermocouple leads, and communication lines, particularly in the chemical processing industry.

Radar Aids in Traffic Control at Highway Intersections

Radar equipment has been harnessed to work as a component in high-efficiency traffic signal control. This development is the accomplishment of Eastern Industries, Inc., Automatic Signal Division at Norwalk, Conn. An installation has recently been put into operation in Norwalk, where eight separate lanes of vehicles converge at a complicated physical layout, and this system has demonstrated its ability to handle traffic with superhuman efficiency. The equipment is now in commercial production and many installations will shortly be made in various streets and highways throughout the country.

With radar detection at a highway intersection, a beam of microwaves from an overhead "eye" is directed down each of the intersecting streets. These "eyes," or perhaps more properly termed antennas, are relatively small units adaptable to mounting on post or arm in such a position that their controlled beam of microwaves is focussed upon oncoming traffic lanes. Installation and adjustment are such that vehicles enter the zone of the beam between 100 and 400 feet from the intersection, depending upon traffic and geographical characteristics.

As each moving vehicle comes to the detection area, the microwaves impinge upon it a portion of the energy being reflected back and picked up by the small overhead antennas. This system of radar detection is sensitive to vehicle motion at all speeds, so that there is supplied to the controller a record of the pattern of approaching traffic. Each vehicle registers its approach but once.

The power required by the radar component of a traffic-actuated signal system is extremely small. Drivers and pedestrians usually are completely unaware of its operation. The radar equipment is unaffected by weather or other normally attendant conditions. The units are designed for ease of mounting and installing, and are ordinarily not noticed by passing traffic. One unit properly positioned and adjusted is sufficient to scan each entering street. It will pick up and send to a highly efficient electronic brain the accurate and around-the-clock picture of the approach pattern of traffic.

Radar added eyes to the traffic controller brains so that they may operate on the demand principle. Approaching vehicles signal their approach, their number, and spacing, so that the actuated controller can respond and apportion the green light in accordance with the ever-changing traffic pattern at the intersection. Thus the right-of-way is allocated on the basis of actual demand and the inefficiency and loss of time caused by the shifting of the green light to an empty street, while impatient motorists wait, is eliminated.

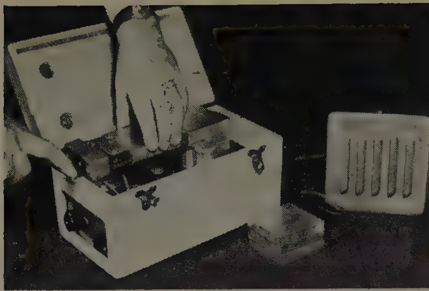
The green light remains on each street for varying lengths of time depending upon changing traffic conditions. The electronic brain guarantees a certain green protection time to each car moving into the intersection on the street having right-of-way. This protection time is reset and retimed for each car as it arrives, thereby cancelling out the unexpired portion of the previous protection time. This process is repeated until a protection time interval expires before a following car is detected. This informs the electronic brain that a gap has occurred in moving traffic of sufficient length to warrant starting traffic on the other street into motion.

A single car waiting against the red light will exert a reducing effect against the allowable gap interval on the opposing street and will make it progressively more difficult for the moving-traffic street to hold the green light.

There are occasionally times when volumes are so heavy that practically bumper-to-bumper conditions occur. If this happens there is an over-all circuit which will shift the right of way at the end of a predetermined maximum time even when radar impulses from traffic moving through the intersection are received at such short intervals that the control is unable to detect a gap interval that would warrant transfer of right-of-way.

Magnetic Tape Player Gives Voice to Displays

The human voice gets just as tired over long periods as the muscles in your back, but until recently not many satisfactory substitutes have been found. An interesting stand-in for the voice is the Salesmaster, manufactured by the Salesmaster Corporation, Los Angeles, Calif. It is an endless magnetic tape player, which can be used in all sorts of situations requiring a substitute for the human voice. Requests have been made for its use at displays in public buildings, in



Versatile magnetic tape recorder

factories for guided tours, as well as to give voice to sales displays and dummies.

The 10-minute time capacity of its tape permits the use of a number of different messages. A regulator on the machine turns itself off and on for varying periods, and advances the tape to the next message. The dial can be set for varying delay periods. To increase its versatility, the instrument has plug-in jacks for a spotlight to shine on the display, a hand microphone, and extra speakers. Also included is an attachment so that the machine can be operated manually by an electronic eye, or can be operated by a person stepping on a carpet over the foot treadle.

NSPE Completes Plans for Headquarters Building

Architectural and engineering plans are nearing completion for the new headquarters building in Washington, D.C., of the National Society of Professional Engineers.

Located in the Northwest section of the Capital, the approximately $300,000 4-story granite-frame building will house the executive and administrative offices of the 33,000-member Society.

Financing of the new headquarters will be handled through the sale of building fund participation certificates to the membership. Contracts for the building will be awarded around the first of the year, and construction will begin in January. The Society plans to occupy the new headquarters by the early fall of 1955.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Induction Heating of Steel

To the Editor:

The design of induction-heating coils for *magnetic* loads is a problem of considerable importance, since the majority of parts heated for forging, hardening, welding, and other purposes are made from magnetic steels. The areas of these parts in which heating currents are induced are subjected to highly saturating magnetic fields, to take advantage of the high-power densities induction heating makes possible. Consequently, the assumption that the hysteresis loop may be approximated by the equation $B=\mu H$, where μ is a constant, is unreasonable.

In the July 1954 issue of *Electrical Engineering*, p. 624, appeared a technical paper digest, "Eddy-Current Phenomena in Ferromagnetic Materials," by H. M. McConnell of the Carnegie Institute of Technology. McConnell's paper (AIEE Technical Paper **54-146**, presented at the Winter General Meeting) shows how $B=\mu H$ where μ is a constant may be replaced by the far more logical assumption $B=+/-B_M$ where B_M is a constant. The plus sign of course applies for H positive, and the minus sign for H negative. McConnell's paper should be compared with the "Approximate Theory" of AIEE Technical Paper **46-124** "Design of Induction Heating Coils for Cylindrical Magnetic Loads," by J. T. Vaughan and J. W. Williamson, published in vol. 66 of the AIEE *Transactions*.

In their "Approximate Theory," Vaughan and Williamson also assume that the hysteresis loop for the load material may be approximated by $B=+/-B_M$, where B_M is a constant. Both articles consider the effect of a sine wave voltage applied to a large-diameter load and arrive at the same waveshape (Vaughan and Williamson's equation 26 or McConnell's equation 22) for the current. This waveshape, along with the instantaneous depth of current penetration δ, is plotted in Fig. 9 of Vaughan and Williamson's paper. The current in the load—or the current through the induction-heating coil—is proportional to the square of the volts to the load per unit of perimeter or circumference.

Still assuming a sine wave voltage applied to the load, Vaughan and Williamson arrive at a theoretical ratio of watts to volt-amperes to the load of 0.895, although their measured ratio of watts to volt-amperes was 0.802. Since complete equations apply in any consistent set of units, their equation 33 may be rearranged slightly and written:

$$\text{Watts per square inch} = 2.52\ (\text{rms ampere turns per inch})^{3/2}\sqrt{\rho B_M f}$$

where the "rms ampere turns per inch" are those acting on the load, ρ is the resistivity of the load in ohm inches, B_M is in webers per square inch, and f is the frequency in cycles per second.

Rather than a sine wave voltage, McConnell now assumes a sine wave current. From his equations 52 and 54, the ratio of watts to volt-amperes to a large-diameter load, for this case, comes out 0.714. McConnell's equation 52, which also assumes a sine wave current, reduces to:

$$\text{Watts per square inch} = 2.53\ (\text{rms ampere turns per inch})^{3/2}\sqrt{\rho B_M f}$$

It is of interest to compare theoretical conclusions with experimental results. Vaughan and Williamson were unable to achieve a pure sine wave of voltage applied to their loads, since the number of magnetic flux lines in the air gap between the load and induction heating coil was appreciable. Therefore, it is easy to see, from the 0.714 ratio (assuming sinusoidal current) of watts to volt-amperes of McConnell's article why Vaughan and Williamson's measured ratio of watts to volt-amperes of 0.802 was less than their calculated ratio of 0.895. Despite the fact that Vaughan and Williamson assume sine wave voltage, while McConnell assumes sine wave current, their relations connecting watts per square inch and amperes per inch in a large-diameter load are identical (within the limits of slide rule accuracy) and may therefore be thought of as a single relation which applies whether either the voltage or current varies sinusoidally with time. Vaughan and Williamson give a check of this relationship at a load temperature of 210 F. While the agreement here is excellent, more checks would be desirable. Above 900 F, with carbon steel loads, compressive mechanical stresses near the outside of the load apparently reduce the flux density B_M, which is therefore very difficult to calculate. I have used the "Approximate Theory" in the article by J. T. Vaughan and myself for load temperatures up to about 900 F with fairly good results.

J. W. WILLIAMSON (M'49)

(Consultant Electrical Engineering, Cleveland, Ohio)

To the Editor:

I wish to acknowledge receipt of the communication by Mr. J. W. Williamson regarding his paper **46-124,** written jointly with Mr. J. T. Vaughan. It was through oversight that I did not refer to that paper in my work on eddy currents. It is encouraging to note that the limiting nonlinear theory has been used successfully in the design of induction heating apparatus.

"Mr. Williamson writes that the ratio of watts to volt-amperes for sine wave current is 0.714, from equations 52 and 54 of my article. He has informed me privately that in computing this ratio, the voltage used was the rms of the nonsinusoidal waveform of my equation 54. Thus the voltage and current are both given as read on rms meters, and the volt-amperes are taken to be the product of these two readings. Perhaps it should be made clear that this product is not the same as the volt-ampere product using fundamental components. It is the latter product which is indicative of the power factor of the eddy-current load, as given in my equation 56."

H. M. McCONNELL (AM'48)

(Carnegie Institute of Technology, Pittsburgh, Pa.)

NOW.. OHMITE® OFFERS

RESISTORS TO MEET MIL-R-26B CHARACTERISTICS

G, F, AND "V"

(HIGH-TEMPERATURE—350° C—CHARACTERISTIC)

IN A WIDE RANGE OF SIZES AND RESISTANCE VALUES

PATENTED, ALL-WELDED CONSTRUCTION!

TAB-TERMINAL TYPE Characteristics G, F, and V

Style	Over-all length	Diameter	*Watts	††Watts
RW-29	1-3/4"	1/2"	8	11
RW-30	1"	19/32"	8	11
RW-31	1-1/2"	19/32"	10	14
RW-32	2"	19/32"	12	17
RW-33	3"	19/32"	18	26
RW-34	3"	29/32"	30	43
RW-35	4"	29/32"	38	55
RW-36	4"	1-5/16"	60	87
RW-37	6"	1-5/16"	78	113
RW-38	8"	1-5/16"	110	159
RW-47	10-1/2"	1-5/16"	145	210

FERRULE-TERMINAL TYPE Characteristics G, F, and V

Style	Over-all length	Diameter	*Watts	††Watts
RW-10	11-7/16"	1-5/16"	140	203
RW-11	9-5/8"	1-5/16"	116	168
RW-12	7-7/16"	1-5/16"	86	125
RW-13	5-1/8"	1-1/16"	50	72
RW-14	4-7/16"	1-1/16"	40	58
RW-15	2-15/16"	3/4"	20	29
RW-16	2-3/8"	3/4"	14	20

FLAT TAB-TERMINAL TYPE (Stack Mounting) Characteristic G

Style	Over-all length	Width of Core	Thickness of Core	†Watts
RW-20	2-1/2"	1-3/16"	1/4"	15
RW-21	3-1/4"	1-3/16"	1/4"	22
RW-22	4-3/4"	1-3/16"	1/4"	37
RW-23	6"	1-3/16"	1/4"	47
RW-24	7-1/4"	1-3/16"	1/4"	63

AXIAL-TERMINAL TYPE Characteristics G and V

Style	Length of Core**	Diameter	†Watts	††Watts
RW-55	1-3/8"	5/8"	5	7
RW-56	2"	5/8"	10	14

*Watts free air MIL Characteristic "F" or "G" **2-1/2" wire leads

†Watts free air MIL Characteristic "G"

††Watts free air MIL Characteristic "V"

EVEN RESISTORS WITH THE FINEST WIRE SIZE (.00175) MEET THE REQUIREMENTS OF MIL-R-26B, CHARACTERISTIC "V"

The Ohmite resistor types shown at the left can withstand a continuous operating temperature of 350° C—the high temperature requirement of MIL-R-26B, Char. "V". These resistors also meet characteristics "G" and "F"—passing severe moisture-resistance and thermal-shock tests . . . withstanding sustained vibration applied for five continuous hours . . . and satisfying the requirements of many other tests.

The Ohmite line of wire-wound resistors is the most extensive on the market. Ohmite also has the most complete line that meets MIL-R-26B specifications. Specify resistors from Ohmite's wide range of types, sizes, and resistance values for your MIL-R-26B requirements and other tough jobs.

OHMITE MANUFACTURING COMPANY
3614 Howard Street Skokie, Illinois
(Suburb of Chicago)

OHMITE®

RHEOSTATS • RESISTORS • TAP SWITCHES

INDUSTRIAL NOTES ....

General Electric Notes. Establishment of a new communication equipment center in Redwood City, Calif., has been announced by the General Electric Company. The new facility will help serve the greatly increased demand for General Electric 2-way radio equipment in the western states. The company will lease a building to be constructed at the corner of Douglas and Broadway in Redwood City. The new center is expected to be completed by the first of the year. Irvin H. Webster has been appointed manager of the new center.

William A. Mulcock has been named regional manager of the company's Air Conditioning Division. His headquarters will be in Chicago, Ill. Mr. Mulcock replaces Lincoln M. Larkin who has resigned to accept the position of sales manager of the Industrial Division of Seeger Refrigerator Company in Evansville, Ind.

Ilsco Changes. Announcement has been made of change in ownership and name of Ilsco Copper Tube and Products, Inc., Cincinnati, Ohio. The company has been acquired by Oliver L. Bardes, Cincinnati industrialist. The name of the company has been changed to Ilsco Corporation. Operations are continuing as in the past with the same management and progressive policies and with Andrew H. Stubbers as president.

Kaiser Aluminum Expansion. Kaiser Aluminum and Chemical Corporation recently has acquired a forging plant at Erie, Pa. The Erie plant can produce aluminum die forgings up to 150 pounds in weight, and has a rated capacity of 12 to 15 million pounds of forgings per year. Acquisition of the Erie plant follows a recent announcement that construction will start about January 1 on a multimillion dollar aluminum sheet and foil rolling mill on an Ohio River site near Ravenswood, W. Va.

Representatives for Standard Transformer. The Standard Transformer Company, Warren, Ohio, has announced the appointment of the Charles L. Ward Company as its exclusive representative in the states of Iowa and Nebraska. The Ward Company maintains offices at 5707 Waterbury Circle, Des Moines 12, Iowa, with Mr. George Swallow, manager; and at 502 Grove Avenue, Corning, Iowa, Mr. Joseph Connolly, manager.

J. L. Howarth Company, 2550 Beverly Drive, Birmingham 9, Ala., has been appointed as exclusive representative for the company in the states of Alabama and Georgia.

Irvington Promotion. Paul L. Hedrick has been assigned as technical service manager for Irvington Varnish and Insulator Division of Minnesota Mining and Manufacturing Company. In his new position Mr. Hedrick will serve as liaison between sales and the research laboratory on the development of new products, with headquarters in the division's home plant and offices at Irvington, N. J.

Director Elected. The Rockland Light and Power Company, Nyack, N. Y., has announced the election of Ralph E. Trower as a director of the company. Mr. Trower, treasurer of Rockland Light and Power since 1948, has been associated with the company for 35 years and was assistant treasurer from 1938 to 1948.

Westinghouse Appointments. A. C. Meixner has been appointed assistant sales manager of apparatus products for Westinghouse Electric Corporation. He joined Westinghouse in 1930. After completing the company's graduate student training course, he was assigned to the transportation and generator sales department, and in June 1941 was named manager of the department's generator section.

Succeeding Mr. Meixner as manager of the generator sales section is C. M. Brinsley who has been in that section since 1942.

Cope Appoints Bradley Company. T. J. Cope, Philadelphia, Pa., has announced the appointment of the Bradley Company, also of Philadelphia, as sales representative for its complete line of cable trough and cable installation equipment. The territory will include: Eastern Pennsylvania, Southern New Jersey, and Delaware.

Carbide and Carbon Appointment. Robert F. Hyland, formerly with the California Research and Development Company, Livermore, Calif., has been appointed to the staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn., an atomic energy installation operated by Carbide and Carbon Chemicals Company, a division of Union Carbide and Carbon Corporation.

General Smith Elected Vice-Chairman. General Walter Bedell Smith, who retired as Under Secretary of State recently, was elected vice-chairman of the board of directors of American Machine and Foundry Company. General Smith will have broad administrative duties and is expected to play a key policy-making role in the company.

NEW PRODUCTS ..

Cathode-Ray tube. The General Electric Company has developed a new 5-inch cathode-ray tube for radar applications, with a high-resolution electron gun pro-

(Continued on page 24A)

Minimize Calibration Time With Versatile, Easy-to-use General Electric Instrument Standardization Console

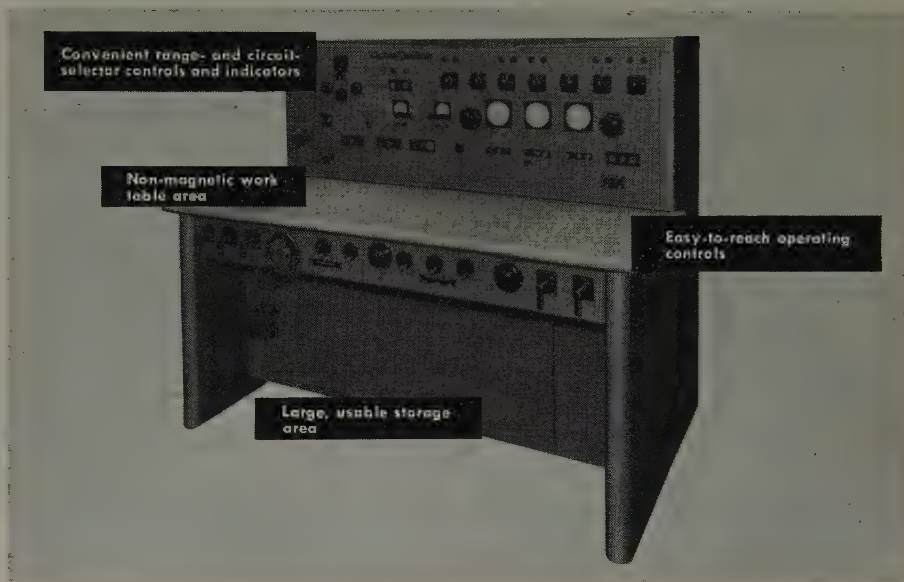
PROVIDES REGULATED POWER SUPPLIES FOR PRECISE INSTRUMENT CALIBRATION

The General Electric instrument standardization console provides regulated power supplies for precise calibration of a wide range of electric instruments.

HIGHLY ACCURATE, the console provides facilities for referring both d-c and a-c measurements to a standard cell, or to a laboratory standard instrument.

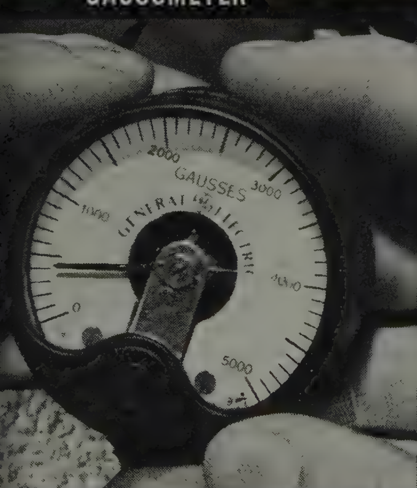
WIDE RANGES of a-c and d-c power supplied by the console facilitate the calibration of voltmeters, ammeters, frequency meters, and many others. Both a-c and d-c standardization tests can be made up to 750 volts, or 150 amperes; with low-distorted a-c frequencies from 50 to 3000 cycles.

FOR FURTHER INFORMATION about the General Electric instrument standardization console, contact your nearest G-E representative, or clip coupon below for Bulletin GEA-6005.



HIGHLY VERSATILE, the General Electric console has necessary switches, busses and indicators for calibration of a-c and d-c laboratory-standard, portable, small-panel, switchboard, and recording instruments. Requires only normal 115-v, 60-cycle source.

GAUSSMETER



CONVENIENT, POCKET-SIZE G-E meter facilitates checks of flux density and direction in magnetic gaps. Ideal for use in small or congested areas. Price including reference magnet and case, $67.10.*

INDICATING FLUXMETER

HIGH ACCURACY AND SENSITIVITY combine to provide precise magnetic measurement. Accuracy is ±1% of full-scale deflection; sensitivity is as high as 1 millimeter deflection per 100 flux lines. Price is $278.50.*

SECTION A605-76
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, N. Y.

Please send me the following bulletins:

- ☐ Instrument Standardization Console (GEA-6005)
- ☐ Instantaneous Vapor Detector (GEC-1275)
- ☐ Photoelectric Recorder (GEC-245)
- ☐ Equipment for Measuring Magnetic Properties (GEC-777)

NAME ....

COMPANY ....

STREET ....

CITY .... ZONE .... STATE ....

GENERAL ELECTRIC

(*Continued from page 14A*)

viding an exceptionally narrow trace on the screen. The tube, type *GL-5FP14-A*, has a maximum line width limit specification of 0.25 mm. In the older *GL-5FP14* type, the maximum line width limit specification was 1.50 mm under similar operating conditions. The decrease in line width, or spot size, means that target identification will be aided considerably. Used in aircraft plan-position indicator equipment, the new tube will allow earlier resolution of closely grouped ground targets. The tube is electrically and mechanically interchangeable with the *GL-5FP14* type. Its high-resolution gun employs smaller apertures in its grid structures. Further information on the tube is available from the General Electric tube department, Schenectady 5, N. Y.

New Monitrans for Color Television. Two new types of monitran transmitters designed for the requirements of color telecasting have been announced by the Engineering Products Division, Radio Corporation of America. Monitrans are used for closed-circuit transmission of video and audio signals to television receivers. The monitran transmitters, which can be used also for black-and-white transmission, are the all-channel *TM-40*, which permits the selection by the user of any television channel from 2 to 13; and the single-channel *TM-41* which is delivered factory tuned to a channel specified by the customer. The all-channel monitran delivers a minimum of 30,000 microvolts into a 72-ohm load, and features 24 crystals for independent control of each of the audio and carrier frequencies from channels 2 to 13. The single-channel monitran delivers a minimum of 500,000 microvolts into a 72-ohm load, and utilizes two separate crystals for the audio and video carriers.

G and W Automatic Operating Mechanism. The G and W Electric Specialty Company has recently developed a new automatic transfer mechanism for use with oil switches, either double-throw or two single-throw units, supplying load from either of two feeders. The mechanism automatically transfers the load from the "preferred" to "emergency" feeder, when the "preferred" feeder voltage fails. It throws back automatically when "preferred" feeder voltage is restored. The mechanical and electrical details are explained in Bulletin Number *DA-F*. Write to G and W Electric Specialty Company, 7780 Dante Avenue, Chicago 19, Ill.

Hartmann and Braun Lumiscript Recorder. The phototrace recorder, Lumiscript, fills a gap for recording minute currents or voltages where a standard recorder is not fast enough, or an oscillograph will be too expensive. Due to its unique luminous recording system, rapidly changing conditions can be traced without distortion. By using a special ultraviolet-sensitive paper, the recording curves become visible immediately without

(*Continued on page 26A*)

(Continued from page 24A)

the necessity of developing the chart. The Lumiscript can be supplied as a single- or a 4-channel recorder with interchangeable, highly sensitive galvanometers, the sensitivities of which range from 0.03 microampere or 0.038 millivolt upwards for 1-mm light spot deflection. Well-damped galvanometer movements for frequencies up to 600 cycles per second are available.

Selenium Rectifiers. Two cartridge-type selenium rectifiers, type *U45HP* and type *U50HPF*, have been developed by International Rectifier Corp., El Segundo, Calif., for use as high-voltage power suppliers in Geiger counters, electrostatic deflection voltage supplies for air-borne equipment, and other similiar instruments requiring a high voltage and low current. Ratings and specifications for these units, plus information on the complete line of cartridge rectifiers for half-wave, bridge, and voltage multiplier circuits, are given in Bulletin *H-2*. Copies are available on request by writing to International Rectifier Corp., 1521 East Grand Avenue, El Segundo, Calif.

Midget 2-Circuit Toggle Switch. New standards of miniaturization have been achieved in a precision toggle switch recently announced by Hetherington, Inc., Sharon Hill, Pa. Called the Hetherington Type *T-2104*, the switch measures only 15/16 inch long by 15/32 inch in diameter. Its unusually small size and high current rating make it well suited for use in modern electric-electronic equipment where tiny true snap-action switches with sufficient current rating and durability have been difficult to find. The switch is rated for currents up to 5 amperes inductive, or 10 amperes resistive. Further details and specifications for this unit are available on letterhead request to the manufacturer.

New Speaker for 2-Way Radio. Motorola is now shipping, as a standard accessory, a new inverted-cone speaker with their mobile 2-way radio units. Advantages of this speaker include: improved intelligibility of messages; universal trunnion mounting; and a unique magnet assembly, which is inside the cone, in order to reduce space requirements. More information can be obtained by writing to Motorola Communications and Electronics, Inc., Technical Information Center, 4501 West Augusta Boulevard, Chicago 51, Ill.

Multiple-Sequence Preset Interval Generator. The new Potter Instrument model *3157* multiple-sequence megacycle preset interval generator provides a convenient means of generating a series of preset time delays adjustable in increments of 1 microsecond. The system includes a 1-megacycle crystal-controlled master oscillator that feeds one or more preset counters capable of producing an output pulse of any desired number of counts (microseconds) after application of a start pulse. For descriptive literature write to Potter

(Continued on page 32A)

KEPCO VOLTAGE REGULATED POWER SUPPLIES

MODEL 615

OUTPUT	VOLTS	CURRENT	REGULATION	RIPPLE
1	0-600	0-300 Ma.	0.5%	5 Mv.
2	0-150 Bias	0-5 Ma.	*	5 Mv.
3	6.3 AC	10 Amp.	†	

MODEL 815

OUTPUT	VOLTS	CURRENT	REGULATION	RIPPLE
1	0-600	0-200 Ma.	0.5%	5 Mv.
2	0-150 Bias	0-5 Ma.	*	5 Mv.
3	6.3 AC	10 Amp.	†	

KEPCO Voltage Regulated Power Supplies are conservatively rated. The regulation specified for each unit is available under all line and load conditions within the range of the instrument.

REGULATION: As shown in table for both line fluctuations from 105-125 volts and load variations from minimum to maximum current.

***REGULATION FOR BIAS SUPPLIES:** 10 millivolts for line 105-125 volts. ½% for load at 150 volts.

†All AC Voltages are unregulated.

30 MODELS

AVAILABLE FROM STOCK
COMPLETE CATALOG ON REQUEST
WRITE DEPT. 24

KEPCO LABORATORIES

131-38 SANFORD AVENUE • FLUSHING 55, N. Y. • INDEPENDENCE 1-7000

(*Continued from page 26A*)

Instrument Company, Inc., 115 Cutter Mill Road, Great Neck, N. Y.

Circon Circuit Connector. The Circon Component Company has introduced their new model *SM4F116* multiple-circuit connector which weighs 0.8 gram and is less than 0.03 cubic inch in volume. It is a 4-contact subminiature female connector for use with 1/16-inch printed circuit, or the Circon model *SM4M116* male connector, and is usable in both printed circuit and conventional cabling applications. For complete information on this or other Circon models, write to Circon Component Company, 17544 Raymer Street, Northridge, Calif.

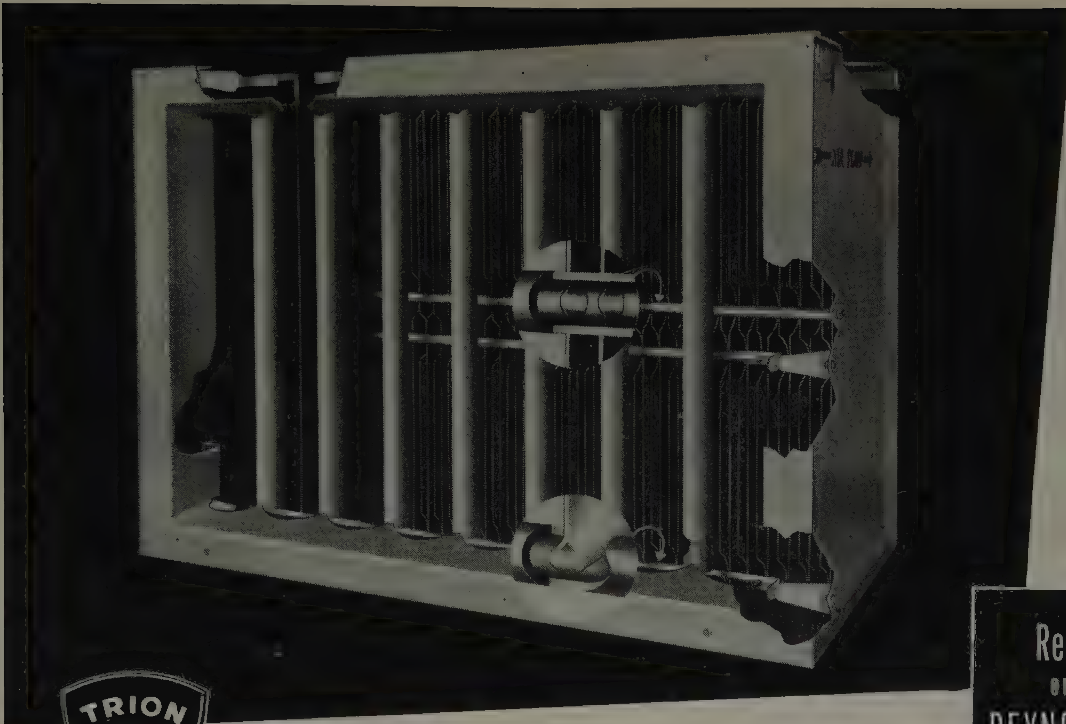
Spray to Protect Aluminum Connections. A new easy-to-use aerosol spray compound called Peneseal has been developed by Burndy Engineering Company to protect all aluminum-to-aluminum and aluminum-to-copper service connections. This nontoxic, noninflammable, nonirritating compound completely seals the connections, maintains low-contact resistance by counteracting the effects of oxide film, and prevents galvanic corrosion. For further details, write Burndy Engineering Company, Inc., Norwalk, Conn.

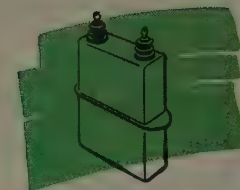
Custom Solenoids From 20 Standard Parts. Joseph Pollak Corporation has announced production of their line of series *100* and *300* d-c solenoids. As many as 300 different types of custom solenoids may be assembled from 20 standard parts. Exact requirements may be met without sacrificing economy, interchangeability, and speed in delivery associated with mass production. Other features include miniature lightweight compact design, maximum power for minimum size, and a wide variety of mountings, coils, and wire sizes. Write for the Solenoid Catalog, Joseph Pollak Corporation, 81 Freeport Street, Boston 22, Mass., for more information.

Subminiature Precision Wire-Wound Potentiometer. Ace Electronics Associates, 125-129 Rogers Avenue, Somerville 44, Mass., has announced a new standard in subminiature wire-wound precision potentiometers. Designated as Number *500* Acepot, this unit is 1/2 inch in diameter, and produces a higher turn per inch, resulting in linearity of $\pm$ 0.3 per cent on standard models. Closer tolerances are available on special order. Electrical and mechanical specifications will be sent by the manufacturer upon request.

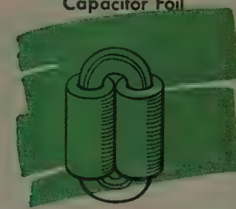
Gibson Refractory Electrical Contacts. Refractory electrical contacts manufactured by Gibson Electric Company have withstood a 5,000-ampere short-circuit test. They have maintained low temperature rise on a new Westinghouse plug-in circuit breaker. The contacts are silver-tungsten Gibsiloy *W-10*, now in use as both the moving and stationary contacts on Quiklag-P circuit breakers manufactured by West-

(*Continued on page 36A*)

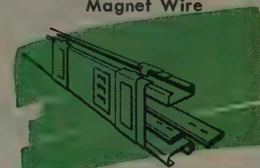




Capacitor Foil



Magnet Wire



Bus Conductor

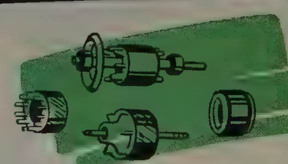
Rely on REYNOLDS : Depend on ALUMINUM in Electrical Applications

Non-Corrosive Aluminum Makes Built-In Washing Unit Possible in Trion Electronic Air Cleaners

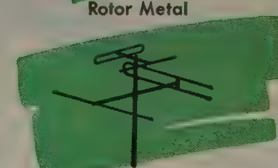
Here a single property of aluminum—resistance to corrosion—provides an obvious reason for its selection. Ionizing-collecting cells in the Trion Electronic Air Cleaner are washed, without being removed, once a week for a period of fifteen minutes. Only with a truly non-corrosive material is this Trion built-in washing feature practical.

As in this case, one aluminum advantage often completely justifies its use. Yet there are invariably other clear-cut benefits. Where aluminum is used because of its high conductivity to weight ratio, its complete workability and adaptability are added advantages. When light weight is its primary advantage, aluminum's strength also adds to its usefulness.

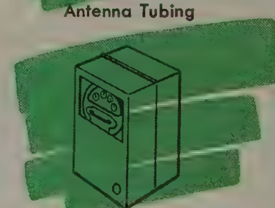
Perhaps Trion's use of Reynolds Aluminum points out possible new aluminum applications in the solution of production or performance problems for your products.



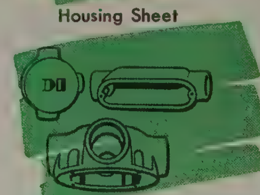
Rotor Metal



Antenna Tubing



Housing Sheet



Fittings Ingot

Call on Reynolds Engineering Service for Help on Your Problems

Reynolds engineers will conduct meetings with your men and provide them with the latest information on electrical applications of aluminum. Also write for a complete index of design and fabrication literature. Reynolds Metals Company, 2541 South Third Street, Louisville 1, Kentucky.

See "Mister Peepers", starring Wally Cox, Sundays on NBC-TV

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

(*Continued from page 32A*)

inghouse Corporation. Gibsiloy *W-10* is exceptional among refractory contact materials because of its high conductivity and high resistance to sticking when interrupting short-circuit currents. Further information can be secured by writing to Gibson Electric Company, 8348 Frankstown Avenue, Pittsburgh 21, Pa.

Stainless-Steel Valve. A stainless-steel solenoid-operated 2-way valve with high resistance to corrosion has been placed on the market by the Automatic Switch Company of Orange, N. J. These Bulletin *8265* stainless-steel valves are designed to control gases and liquids generally corrosive to bronze, steel, or iron at pressures up to 250 pounds per square inch. They are normally closed (close when de-energized, open when energized) valves. Continuous-duty Class *A* coils for temperatures up to 212 F are provided. High-temperature Class *H* coils are supplied for temperatures to 450 F. Further information and literature are available from the manufacturer. Write to Automatic Switch Company, 391 Lakeside Avenue, Orange, N. J.

Unique Low-Noise Traveling-Wave Tubes. Development of two unique types of RCA low-noise traveling-wave tubes with greater efficiency, range, and sensitivity in microwave radio applications has been disclosed by the Tube Division, Radio Corporation of America. These tubes, still developmental but available to industry on a sampling basis, are an *S*-band type, for use in the input stage of microwave receivers and amplifiers operating over a frequency range from 2,700 to 3,500 megacycles, and a *C*-band type, for use in microwave relay applications covering the frequency range from 5,900 to 6,900 mc. The tubes offer an important solution to the problem of microwave amplification, since in many applications a reduction in the receiver noise level is equivalent to a corresponding increase in transmitter output. This will result in increased sensitivity of microwave equipment over greater ranges. The *S*-band traveling-wave tube will operate in a solenoid with a noise figure less than 10 db for a gain of 20 db.

Large A-C Transformers. Newly developed tap changers for de-energized operation are now standard equipment on large Allis-Chalmers transformers. Principal features of the new transformer mechanism are the design of its contact area and a flexible action which keeps equal pressure on moving members so they are self-aligning. Springy arms hold a pair of rounded, movable solid-copper bridging contacts firmly against a cylindrical-shaped stationary contact. The stationary contacts are located in a semicircle around the tap changer panel assembly ready to receive the movable contacts as the operator changes the bridging arrangement. The design is such that no current whatever passes through the springs.

Fuel Indicating System. A new electronic fuel measurement system for aircraft in

(*Continued on page 44A*)

(*Continued from page 36A*)

which a single amplifier power unit serves several indicators by receiving and sorting signals from two different fuel tanks at the same time has been announced by the Aeronautical Division of Minneapolis-Honeywell Regulator Company. The new system eliminates one power amplifier for every two indicators. This simplifies installation and reduces both cost and weight. For a 3-unit installation using a separate tank sensing element, power amplifier, and cockpit indicator, the power unit can be provided with either vacuum tubes or transistors. Also available is a 2-unit system in which the transistorized power unit is with the combined indicator. The Multiplex system meets the accuracy requirements of MIL *G-7818* and is available with either factory preset or external adjustments on either the vacuum tube or transistorized type of power amplifiers.

TRADE LITERATURE

Radio and Electronic Equipment. Allied Radio Corporation of Chicago, Ill., distributors of radio and electronic parts and equipment, have announced the release of their 1955 General Catalogue Number *140*. The new catalogue contains 308 pages, listing over 25,000 items. Special emphasis is on equipment for industrial maintenance, research, and production requirements. Featured also is the RCA "TV Eye," a moderately priced television camera, operated by remote control. A rotogravure section lists the Knight Underwriters Laboratories' approved public address amplifiers in systems ranging from 8 to 80 watts. There is public address equipment for every industrial application. There is also a complete section on recording equipment, and all recording accessories are listed. A technical book section includes leading publications covering theoretical and practical aspects of radio, electronics, and electricity. This new 1955 buying guide may be obtained without charge upon request. Write to Allied Radio Corporation, 100 North Western Avenue, Chicago 80, Ill.

Load Center Transformers. A 20-page brochure on load center transformers has been published by R. E. Uptegraff Manufacturing Company. These transformers are made in ratings up to 2,500 kva and are designed for use as near as possible to the center of the load, thereby minimizing costly low-voltage runs and improving power characteristics. Copies of Catalogue Number *132* may be obtained from R. E. Uptegraff Manufacturing Company, Scottdale, Pa.

Gas Turbines for Pipeline Pumping. A publication explaining the application of gas turbines for gas pipeline pumping is available from General Electric Company, Schenectady 5, N. Y. The booklet is designated *GEA-5962*.

RUBBER INSULATION—0 to 5kv

the complete story on

UNSHIELDED POWER *and* CONTROL CABLE

Here's the complete story on unshielded Okolite-Okoprene power and control cable. Under one cover in Okonite's new 128 page Bulletin EG-1085 you will find:

1. ***CONSTRUCTION FEATURES***
   Okoloy conductor coating, Okolite insulation, Okoprene sheath, Okonite's exclusive strip-insulating process, why 5kv unshielded cables are best.

2. ***ENGINEERING INFORMATION***
   electrical formulas, current-carrying capacities, resistance ratios, voltage regulation, short circuit currents, complete dimensional data for aerial, duct, and direct burial constructions.

3. ***INSTALLATION AND HANDLING TECHNIQUES***
   conduit and direct burial installation, proof-testing after installation, periodical maintenance tests.

4. ***SPLICING AND TERMINATING***
   drawings and instructions for straight and tee splices, indoor and outdoor terminals, splices to paper and varnished cambric cables.

If you need a cable for 4160 volt operation, remember Okonite can supply it *unshielded* . . . assuring reduced installation costs as well as easier splicing and terminating. Okolite-Okoprene does *not* have to be shielded at 5kv because the Okoprene sheath is highly resistant to corona cutting and has high surface resistivity. This limits the magnitude of longitudinal drainage currents which can flow to ground at a contact point, thereby preventing cable burning.

Write for Bulletin EG-1085 today. The Okonite Company, Passaic, New Jersey

OKONITE SINCE 1878 ***insulated cables***

2753

Lap welding tool (left) and butt welding tool as manufactured and sold by Utica Drop Forge & Tool Corporation under license from Koldweld Corporation.

SEE what's happening to *COLD* PRESSURE WELDING OF ALUMINUM

New developments in cold pressure welding of aluminum mean that NOW, up to ⅛″ aluminum wire for transformers, solenoids, reactors and motors can be welded *instantly and inexpensively.*

A pressure butt welding tool (see photograph) is used to produce continuous lengths of wire as well as to mend breaks. Manufacturers of stranded and spooled aluminum wire and cable are assured of uninterrupted, continuous operation.

For instantaneous cold pressure welding of aluminum sheet and foil, a lap welding tool is used (see photograph). A typical application is the completion of electrical connections between foil or thin sheet—as in electrical foil for condensers.

Any electrical manufacturer can benefit by using this new aluminum welding process.

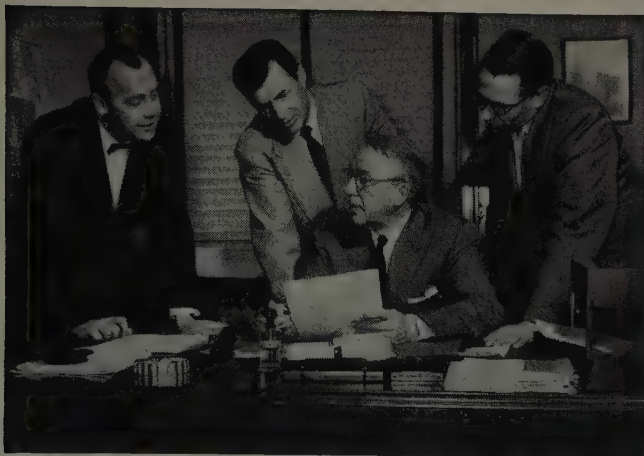
To find out how the latest developments in cold pressure welding can be used to advantage in *your* manufacturing operation, write Alcoa. Alcoa's research and development facilities—*and extensive experience with cold pressure welding of aluminum*—are at your service just for the asking.

The coupon on the page at right will save your time. Mail it today.

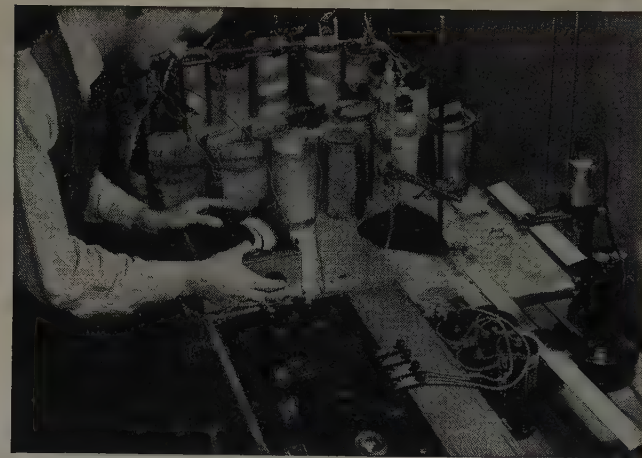
ALCOA ALUMINUM

ALUMINUM COMPANY OF AMERICA

TO HELP IN YOUR PROJECTS, ONLY ALCOA OFFERS



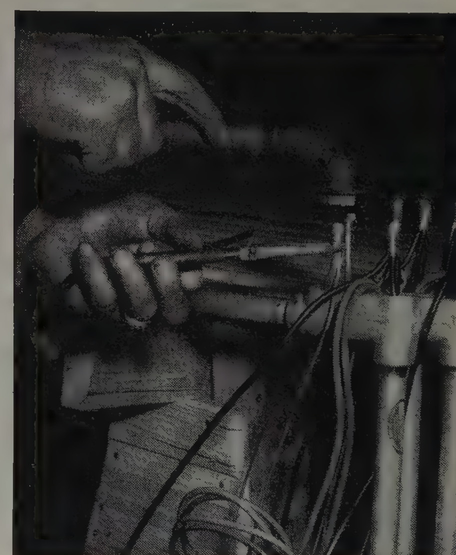
1. KNOWLEDGE AND SPECIALISTS IN ELECTRICAL MANUFACTURING . . . Among the specialists at the Alcoa Development Division are men already familiar with the problems of electrical manufacturing. Their knowledge of practical problems of fabrication and costs, gained in thousands of projects, can help you in every phase of yours.

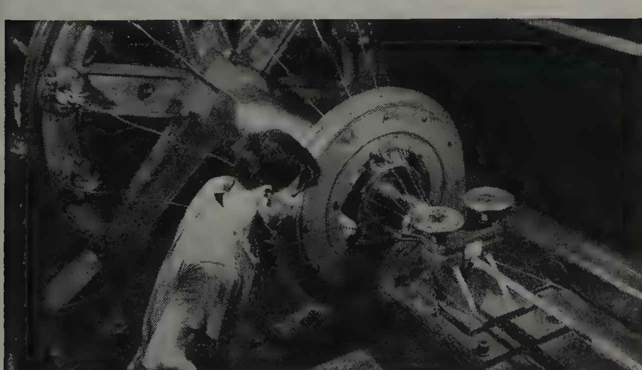


2. FACILITIES FOR BROAD RESEARCH . . . Perhaps your project will require only routine research. But if you must probe into the basic nature of aluminum—its alloys, strength, chemical and physical properties—Alcoa has the facilities. Facilities which developed most of the aluminum alloys in use today.

3. ADVANCED TEST EQUIPMENT . . . Whether you want to check the soundness of your new product by X-ray or test it under a load of 3,000,000 pounds, the equipment is here to do it.

4. SHOPS FOR PROCESS DEVELOPMENT . . . Alcoa makes available all the techniques of joining, forming, machining, casting, heat-treating and finishing to create a practical pilot model, then suggests low-cost, efficient methods for its fabrication. Here you see carbon arc welding of aluminum wire electrical connections.





5. PRODUCTION FACILITIES FOR ALUMINUM IN EVERY COMMERCIAL FORM . . . Aluminum from Alcoa in *every* commercial form—forged, cast, extruded, rolled and drawn—to make your product sell better, last longer, cost less to build.

Aluminum Company of America
2102-M Alcoa Building, Pittsburgh 19, Pa.

I am interested in cold pressure welding of aluminum. Please send to me at no obligation:

☐ Sample of cold pressure welded aluminum wire.

☐ 176-page manual, *Welding Alcoa Aluminum.*

Further information on ____________________

____

Name ____________________

Title ____________________

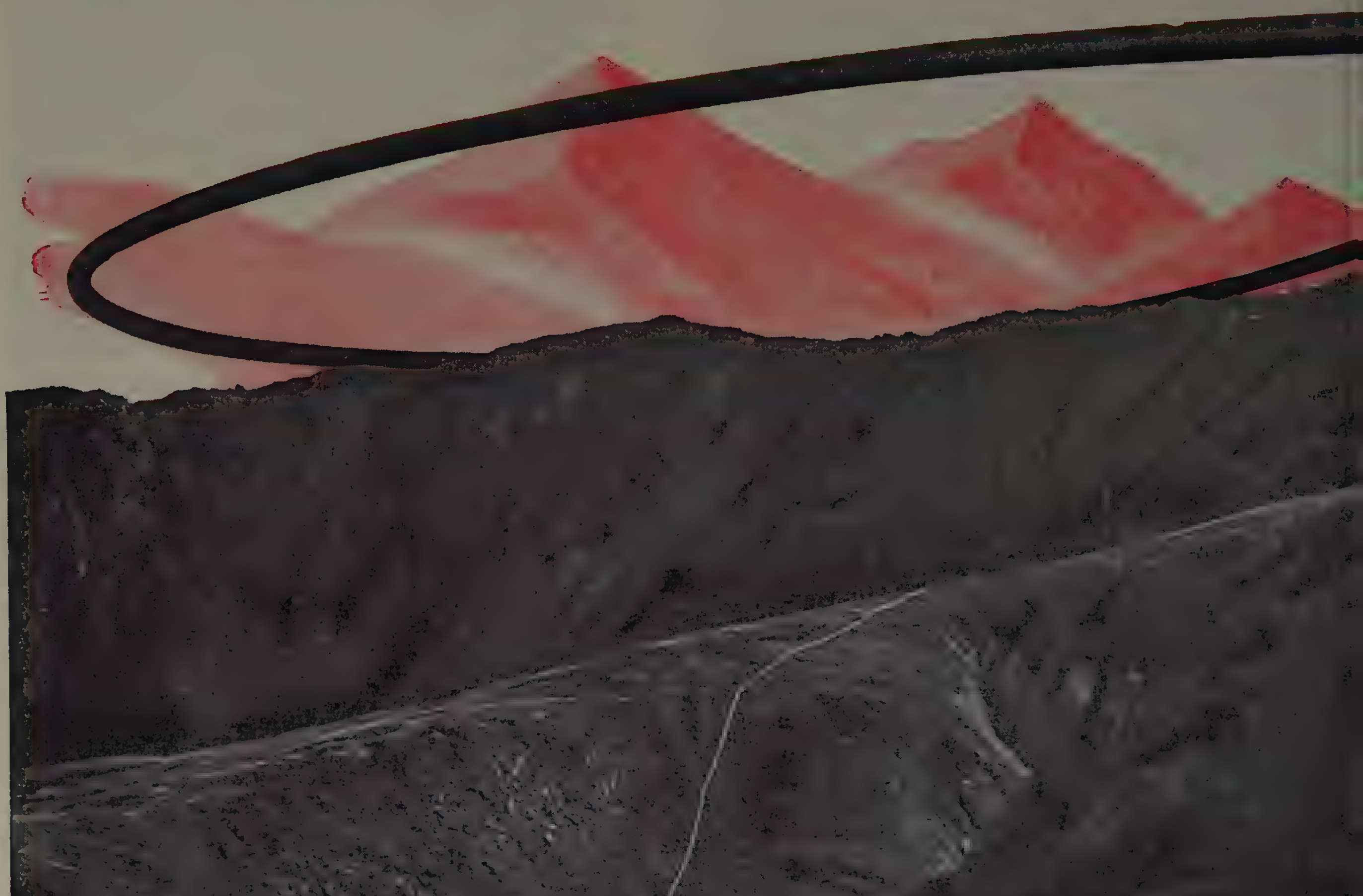
Company ____________________

Address ____________________

City __________ ZONE __________ State __________

ALCOA . . . FOR 66 YEARS, AMERICA'S LEADING SUPPLIER OF ALUMINUM

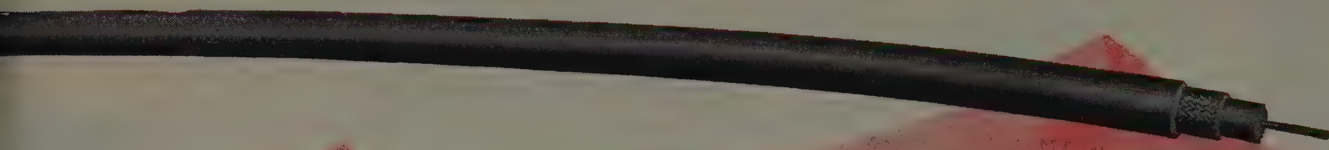
THE WORLD'S HIGHEST COMMUNITY



Reflected sunlight makes the primary cable look like a white line running down the slopes of Mt. McNamee. Except for a section of conduit that is buried beneath the road, at center, the entire 4300 ft. of cable between summit and mine lies exposed on the ground.

Stringing RG-11U cable on existing telephone poles. RG-11U was used as secondary lead, and as drop cable to individual outlets.

TV SYSTEM IS ROUGH ON CABLE



COAXIALS MUST WITHSTAND RUGGED TERRAIN, SNOW, HIGH WINDS, AND LIGHTNING IN THE 13,783 FT. INSTALLATION AT CLIMAX, COLORADO

Taking antenna field strength readings atop 13,783 ft. Mt. McNamee.

Installation crew watching the first TV reception on test equipment in the amplifier shack. In normal operation, the insulated 6′x6′ metal building houses the front end amplifier equipment for the community antenna system.

This unique TV distribution system, provided for its employees by the Climax Molybdenum Co., makes use of two transmission cable types. Both are insulated with BAKELITE Polyethylene and jacketed with BAKELITE Vinyl Plastic – providing service that underscores the outstanding electrical and mechanical properties of these wire covering materials.

From the antenna site at the peak of nearby Mt. McNamee, the primary lead—Federal K-14 cable—descends 11,000 linear ft. to the community. During its course, this cable lies on the ground, exposed to the elements . . . is buried in conduit . . . and for 4900 ft. runs through the underground workings of the mine in conduit and on messenger. From the edge of town, 80,000 ft. of pole-strung Federal RG-11U cable, serving as secondary lead and drop cable, continues the transmission to some 500 TV receivers. Throughout these long cable runs, the superior mechanical characteristics, the constant impedance, low line loss, and low power factor of BAKELITE Vinyl Plastics and BAKELITE Polyethylene prove big factors in maintaining the TV signal at essentially the same quality as received at the antennas. The first amplifier necessary in the primary cable *is 2400 ft. from the front end equipment on the mountain peak.*

Two antenna groups receive channels 2, 4, 7, and 9 from Denver stations, about 60 air miles away. The first antennas suffered considerable damage from icing and high winds, and had to be replaced with sturdier structures. The coaxial cables however, insulated with BAKELITE Polyethylene and jacketed with BAKELITE Vinyl Plastic, measured up to expectations from the very first. Note the loose, broken rock, typical of the terrain along the course of the primary cable.

Wire and cable jacketing made of BAKELITE Vinyl Plastics is wax-smooth—for easier pulling and stripping. Compounds can be formulated to stay pliable in very low temperatures . . . resist deformation in extreme heat. Lasting colors provide permanent coding. BAKELITE Polyethylene is light, permits smaller diameters—for easier handling, savings in space and weight. Cores of this material stay tough and flexible . . . hold their excellent electrical properties through a wide temperature range.

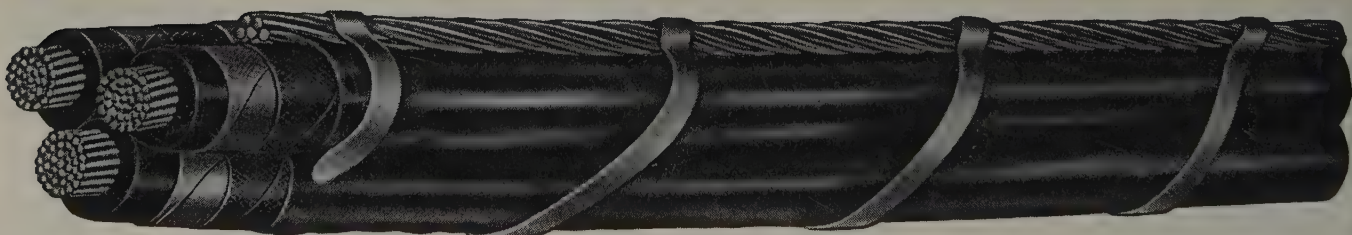
For all the facts on BAKELITE Vinyl Plastics and BAKELITE Polyethylene for wire coverings, and names of your nearest suppliers, write Dept. AC-66.

Data courtesy of: **Climax Molybdenum Co.,** Climax, Colorado; **Federal Telephone and Radio Company,** Clifton, N. J., a division of IT&T.

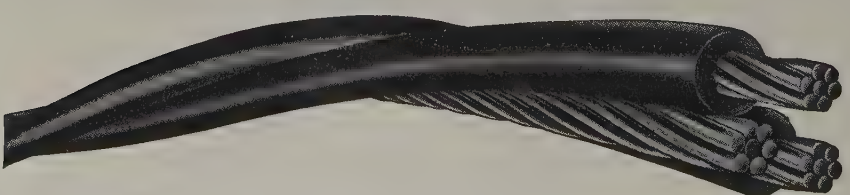
BAKELITE
TRADE-MARK
PLASTICS

TRADE MARK

BAKELITE COMPANY
A Division of
Union Carbide and Carbon Corporation
UCC
30 East 42nd Street, New York 17, N. Y.



(ABOVE) **Rome Pre-Assembled Self-Supporting Aerial Cable For Primaries**—Supplied in various designs incorporating RoZone insulation, shielding where needed (generally over 5 KV) and outer protecting coverings of RoPrene (Neoprene) or corrosion-resistant metallic tape in accordance with IPCEA standards.



(LEFT) **Rome Triplex Self-Supporting Secondary or Service Drop Cable**—RoPrene (Neoprene) or RoLene (polyethylene) insulated copper or aluminum power conductors spiraled around a suitable neutral messenger of copper, copperweld, aluminum or ACSR.

Guard against this nightmare

Wind and ice loading are kept at a minimum by Rome self-supporting cables. They reduce cross-arms and permit shorter poles.

Fewer accessories, reduced cable cost and cleaner, neater installations result from using Rome Triplex service drop cable.

Poles top-heavy with crossarms and wires. A vicious ice storm. Heavy winds. Broken poles and wires. It is the nightmare of power outage and costly replacements.

You can minimize this expense and customer dissatisfaction by standardizing on Rome self-supporting cables.

Manufactured to your specification, with either copper or aluminum conductors, Rome self-supporting cables utilize the time-proven construction of insulated power conductors spiralled around, or bound to a neutral or supporting messenger. These cables are mechanically predesigned, with a large factor of safety, to anticipate ice and wind loading.

Low installation and maintenance costs

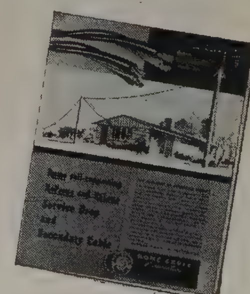
You will realize substantial savings with Rome self-supporting cables, both in installation and maintenance. Crossarms can be eliminated, less hardware is required and, often, fewer poles because of longer spans. Maintenance costs are lower, too. Requiring no common covering, conductors are readily accessible for easy taps. Tree trimming is minimized through excellent resistance to abrasion.

Longer service life in all weather

Insulated or sheathed with RoLene (polyethylene) or RoPrene (Neoprene), Rome self-supporting cables are unaffected by sunlight, moisture and corrosive atmospheres. There are no fibrous braids to rot and festoon. Replacement is kept to a minimum. Better voltage regulation is, also, a factor because of lower reactance due to the close spacing of insulated conductors in long or heavily loaded circuits.

Whether for 600 volts or 15,000 volts, if it is going overhead, it will pay to do as so many others are doing... check the advantages and economies of Rome self-supporting cables. They are cables engineered to the service involved. The coupon below will bring you information on their properties and characteristics.

You'll find a wealth of helpful information on physical and electrical characteristics, specifications, dimensions and installation data on these and other Rome wires and cables in Bulletin RS-5. Mail the coupon.



ROME CABLE Corporation

ROME · NEW YORK *and* TORRANCE · CALIFORNIA

ROME CABLE CORPORATION, Dept. EE-12, Rome, N. Y.

Please send copy of.... Bulletin RS-5.

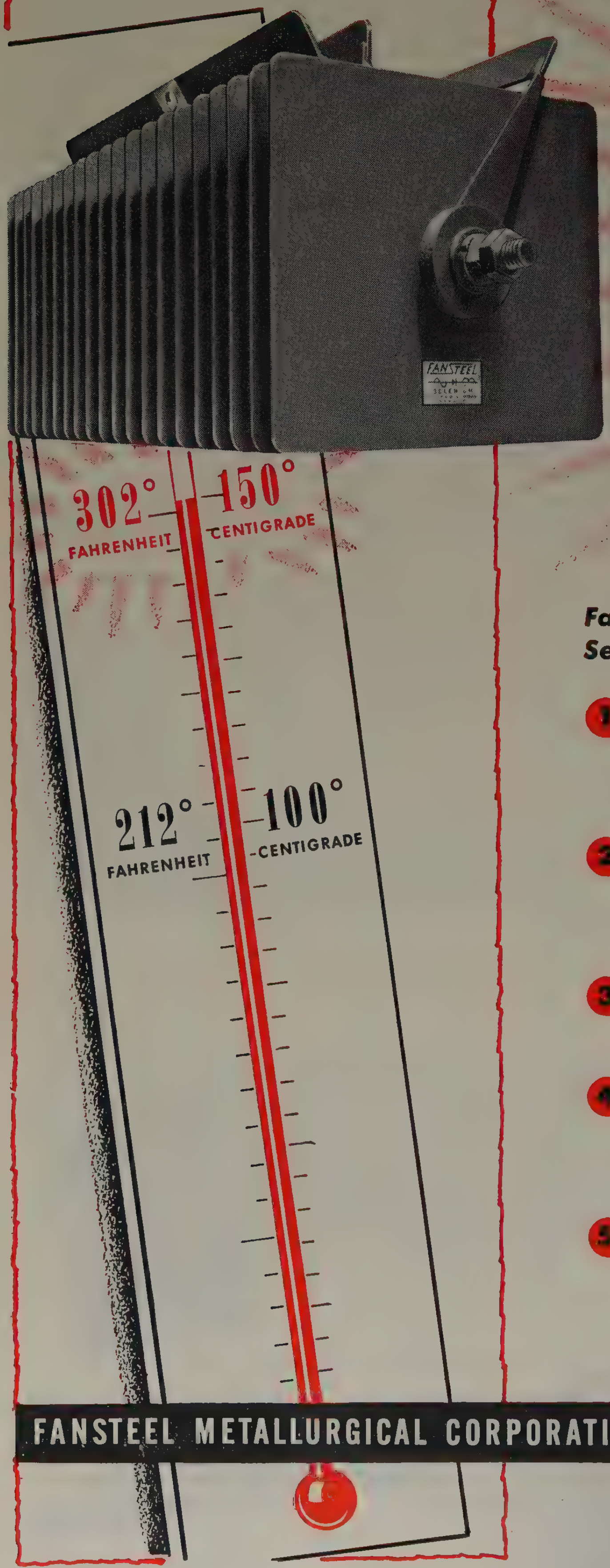
Name..

Company..

Address..

City........................ Zone........ State..........

. . . another "FIRST BY FANSTEEL"



NEW RECTIFIER DELIVERS FULL RATED POWER at 100°C (212°F)

NORTH CHICAGO, ILL.—A new type of selenium rectifier, intended for operation at temperatures substantially above the limits of conventional, o... has been announced at t...

Fansteel announces an entirely new Selenium Rectifier:

1. Able to operate at 100°C (212°F) and deliver full rated power output, continuously, with no *derating whatever*.
2. Able to operate at ambient temperatures up to 150°C (302°F) with only moderate derating.
3. Available in all standard cell sizes and all standard circuit arrangements.
4. Available with all standard protective finishes—moisture resistant, salt-spray resistant, fungus resistant.
5. Now in production for specialized applications. Tell us your problems and we will make recommendations.

FANSTEEL METALLURGICAL CORPORATION NORTH CHICAGO, ILLINOIS, U.S.A.

30 YEARS of DEPENDABLE RECTIFIERS

E543

AVAILABLE FROM STOCK FOR IMMEDIATE DELIVERY

BY IRVINGTON

POLYESTER FILM LAMINATED INSULATION

IN OVER TWENTY COMBINATIONS

Class A and Class B varieties to meet your requirements

Irvington stocks — for immediate delivery in any quantity — many varieties of polyester film laminated with kraft or rag . . . woven glass or asbestos . . . in duplex and triplex constructions.

The exceptional dielectric strength and heat stability of tough, strong polyester film make it ideally suited for slot and phase insulation in today's compact motors, and for coil, relay and dry type transformer insulation.

SPECIAL ADHESIVES PREVENT DELAMINATION

To the unequaled advantages of polyester film Irvington has made a further contribution: the development of special adhesives for bonding the film to all common Class A and B materials. Impervious to heat or solvents, these adhesives provide effective insurance against delamination.

Write for technical data and a folder containing samples of some of the hundreds of combinations available from Irvington.

Look to
IRVINGTON
for Insulation Leadership

- INSULATING VARNISHES
- VARNISHED CAMBRIC
- VARNISHED PAPER
- VARNISHED WOVEN GLASS
- INSULATING TUBING
- CLASS "H" INSULATION

IRVINGTON VARNISH & INSULATOR

DIVISION OF MINNESOTA MINING & MANUFACTURING COMPANY

3 ARGYLE TERRACE, IRVINGTON 11, N. J. • PLANTS: IRVINGTON, N. J.; MONROVIA, CALIF.; HAMILTON, ONTARIO, CANADA

"Our Tiger Brand

NOTICE THE CABLE TRAY fastened to the shovel. This was developed by Universal Atlas for easier cable handling.

TWO WORKMAN WATCH from blast shelter as charge is set off in distance. Low horses cushion cable from shock of falling rock.

HERE A CABLE is raised on horses to clear the railroad track. It feeds the shovel visible in background.

AIEE REPORTS

These publications are proposals for new standards or test codes, or revisions of present publications, which are in the formative stage.

They are made available, without cost, so that all interested individuals may obtain them for study and comment, thereby supplying practical experience in their use before submission for adoption.

1A General Principles for Rating of Electric Apparatus for Short-Time Intermittent or Varying Duty (September 1941)

1C Test Code for Evaluation of Systems of Insulating Materials for Random-Wound Electric Machinery (January 1954)

51 Guiding Principles for Dielectric Tests (September 1949)

52 Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases (March 1951)

53 Proposed Guide for Operation and Maintenance of Dry Type Transformers with Class B Insulation (October 1952)

54 Standard, Test Code, Recommended Practice for Induction and Dielectric Heating Equipment (October 1952)

56 Insulation Maintenance Guide for Large AC Rotating Machinery (May 1954)

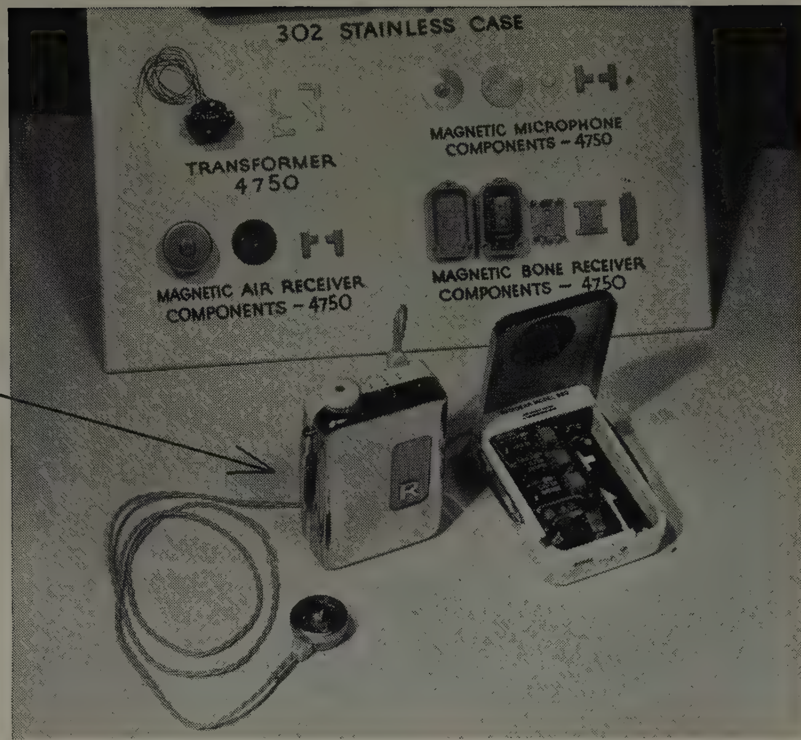
502 Test Code for Single-Phase Motors (November 1941)

504 Test Code for Carbon Brushes (October 1953)

No charge for copies

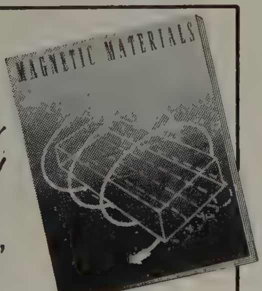
American Institute of Electrical Engineers
33 West 39th St., New York 18

for
HEARING AIDS



or
RECORDING HEADS

or *ANY* MAGNETIC MATERIALS JOB . . .



Write for your Copy
"MAGNETIC MATERIALS"

This 32-page book contains valuable data on all Allegheny Ludlum magnetic materials, silicon steels and special electrical alloys. Illustrated in full color, includes essential information on properties, characteristics, applications, etc. Your copy gladly sent free.

ADDRESS DEPT. EL-60

You can *rely* on core materials like the Allegheny 4750 components illustrated above, in your receivers, recording heads or microphone assemblies.

In fact, whether your equipment is small or large, the extra-broad line of A-L magnetic materials will solve your magnetic core problems. It includes all grades of silicon steel sheets or coil strip, as well as Allegheny Silectron (grain-oriented silicon steel), and a wide selection of high-permeability alloys such as 4750, Mumetal, Permendur, etc.

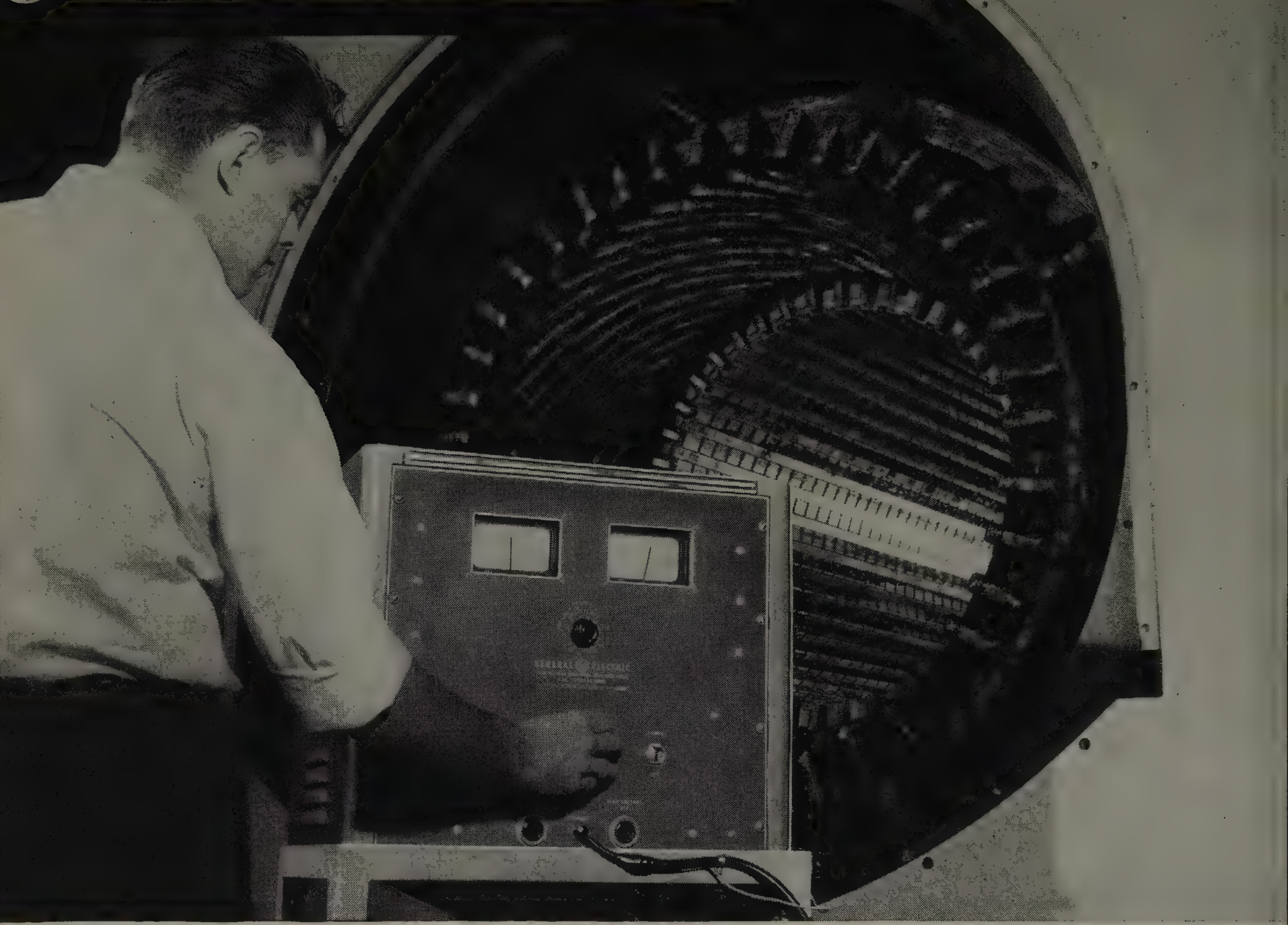
Our service on these materials also includes complete facilities for the fabrication and heat treatment of laminations. (For users of electrical sheets and strip, our lamination know-how is a real bonus value!) Either way, we'll welcome the chance to serve you. *Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa.*

STEELMAKERS to the Electrical Industry
Allegheny Ludlum

W&D 5335

AL®
STEELS FOR THE ELECTRONIC AGE

Developments in Insulation and Resistance Testing



PREVENT UNTIMELY FAILURES of vital equipment like this generator stator by making non-destructive insulation tests with General Electric's new 10-kv insulation-resistance tester. Resistance measurements of installed equipment make it possible to follow insulati deterioration so that the equipment can be removed from servi before the danger point is reached. Price of equipment is **$1825.2(**

More News About General Electric Instruments for Insulation and Resistance Testing

INSULATION-RESISTANCE METER

UP TO 20,000 MEGOHMS may be quickly and accurately measured on four scales of the insulation-resistance meter. With output current limited to 2 ma, greater safety for operator is assured. **$304.20.***

HIGH-POTENTIAL TESTE

CURRENT-LIMITED to a maximum of 5 mil amperes, the G-E high-potential test minimizes most of the hazards encounter with other such equipment. No barrie cages or white tape are needed. **$195.00**

**Manufacturer's suggested retail price.*

GENERAL ELECTRIC ANNOUNCES . . . .

NEW 10-kv Insulation-Resistance Tester; Accurately Reads up to 200,000 Megohms

Non-destructive Tests with G-E Tester Will Help To Foretell the Failure of Expensive Equipment

Now, with only one instrument, you can measure insulation resistance from 0 to 200,000 megohms at 10,000 volts d-c.

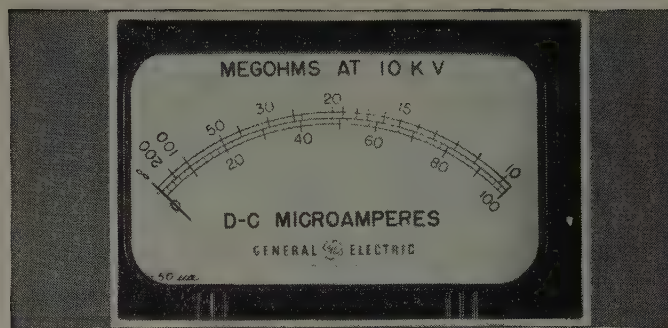
Because of this broad range, the new General Electric 10-kv insulation-resistance tester can be used to check the quality of insulation in equipment with high dielectric capacities. Such tests made before over-potential tests can help prevent the failure of expensive equipment.

MAXIMUM ACCURACY is obtained, even if the source voltage fluctuates widely, because the input of G.E.'s new insulation tester is stabilized by a synchronous motor-generator set.

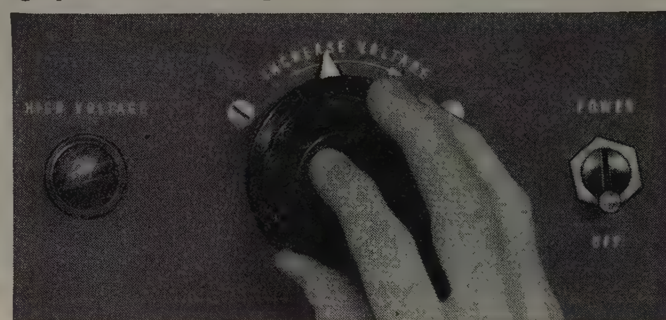
CONTINUOUSLY ADJUSTABLE OUTPUT—With the 10,000-volt d-c voltage output, which can be adjusted continuously down to zero, resistance measurements can be made near the operating voltages of the equipment. This eliminates the misleading measurements that are often made when tests are not conducted under simulated operating conditions.

VALUABLE TIME IS SAVED in making non-destructive insulation tests of equipment with large capacitances because they can be charged quickly.

For more information, contact your nearest G-E Apparatus Sales Office or mail coupon below.



FASTER TESTING is possible with G.E.'s new 10-kv insulation-resistance tester. Resistance can be read directly from the scale for the voltage specified when ordering eliminating time-consuming calculations.



OUTPUT IS CONTINUOUSLY ADJUSTABLE over the 10,000-volt range by means of this knob so that resistance measurements can be taken at or near the normal operating level of the equipment being tested.

10-KV WINDING-INSULATION TESTER

FAST, SIMULTANEOUS TESTS of turn-to-turn, coil-to-turn, and coil-to-ground insulation can be made with G.E.'s 10-kv winding-insulation tester. Dissymmetry of windings as small as one turn can be quickly detected. **$2909.40.***

SECTION A605-83
GENERAL ELECTRIC COMPANY
SCHENECTADY 5, N. Y.

Please send me the following bulletins:

- ☐ 10-kv Insulation-Resistance Tester (GEC-1276)
- ☐ 10-kv Winding-Insulation Tester (GEC-321)
- ☐ Insulation-Resistance Meter (GEC-753)
- ☐ High-Potential Tester (GEC-700)

Name..

Company..

Street..

City.............................. Zone........ State..............

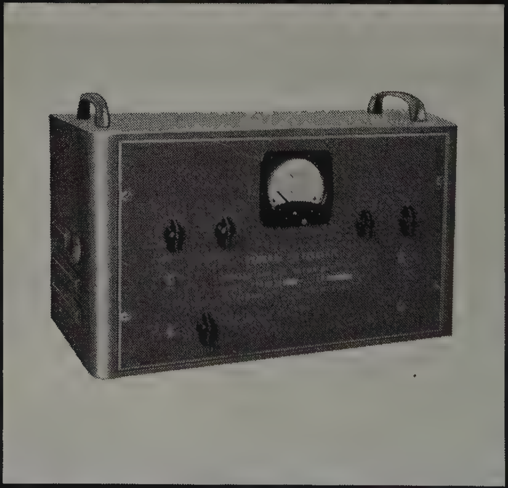
GENERAL ELECTRIC

Developments in Laboratory Instruments

TO SAVE VALUABLE MAN-HOURS, G-E CONSOLE IS FUNCTIONALLY DESIGNED FOR SIMPLE OPERATION; FEATURES EASY-TO-REACH CONTROLS

News About Other General Electric Instruments for Precision Measurement in the Laboratory

INSTANTANEOUS VAPOR DETECTOR



FOR HEALTH MONITORING of mercury vapor and certain other toxic vapors, this portable General Electric instrument pinpoints contaminated areas; can be used wherever 115-v., 60-cycle power is available. $495.00.*

PHOTOELECTRIC RECORD

RECORDING RAPIDLY CHANGING PHENOMENA with minimum load on measure circuit, recorder is available with sensitivity as low as 1 ua full scale. Response times as low as 1/5 second. $700.00

*Manufacturer's suggested retail price.

Pouring power into a giant of steel

Dramatic symbol of America's industrial might, U. S. Steel's big Fairless Works is completely new—a giant at birth! From foundations to furnaces, here is an outstanding example of industrial foresight and planning.

Among this huge mill's many impressive innovations is its planned system of power distribution. Substations, switchgear, and circuit breakers—channeling power throughout this giant of steel—are strategically located to provide maximum protection, control, and continuity of service.

Installation of *only the finest* of equipment has been a long tradition at U. S. Steel. Electrical distribution equipment—of fundamental importance—has to be rugged and dependable to fulfill these vital requirements.

at U.S. Steel's new FAIRLESS WORKS

kilowatts for a colossus feed through switchgear and circuit breakers built by I-T-E

Some 70 modern indoor and outdoor I-T-E Unit Substations transform and distribute power throughout the mill. I-T-E Low-Voltage and Metal-Clad Switchgear, as well as Heavy-Duty I-T-E Circuit Breakers, guard the many critical steel processes.

From the start, I-T-E gave important engineering assistance in the preparation of specifications and in expediting *switchgear* orders for the Fairless Works. As a result of this close cooperation, power distribution equipment was on the ground *when needed* to fit right in with tight construction schedules.

Traditionally a supplier of U. S. Steel, I-T-E is proud of its place as a *major* contributor of quality power distribution equipment for the new Fairless Works.

AT FAIRLESS—

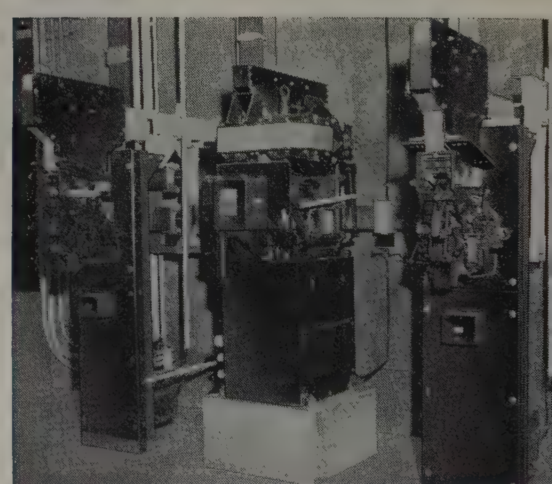
I-T-E Switchgear protects:

rolling mills	**open hearths**
coke ovens	**maintenance shops**
power house auxiliaries	**office building**
billet mills	**car dumper**
strip mill	**ore dock**
blast furnaces	**oil bulk storage**

For details, contact the I-T-E field office nearest you. Look in your classified directory under "Electric Equipment."

I-T-E METAL-CLAD SWITCHGEAR
installed in cold mill for 2400-volt distribution.

I-T-E LOW-VOLTAGE SWITCHGEAR
installed in sheet and tin mill for 480-volt distribution.



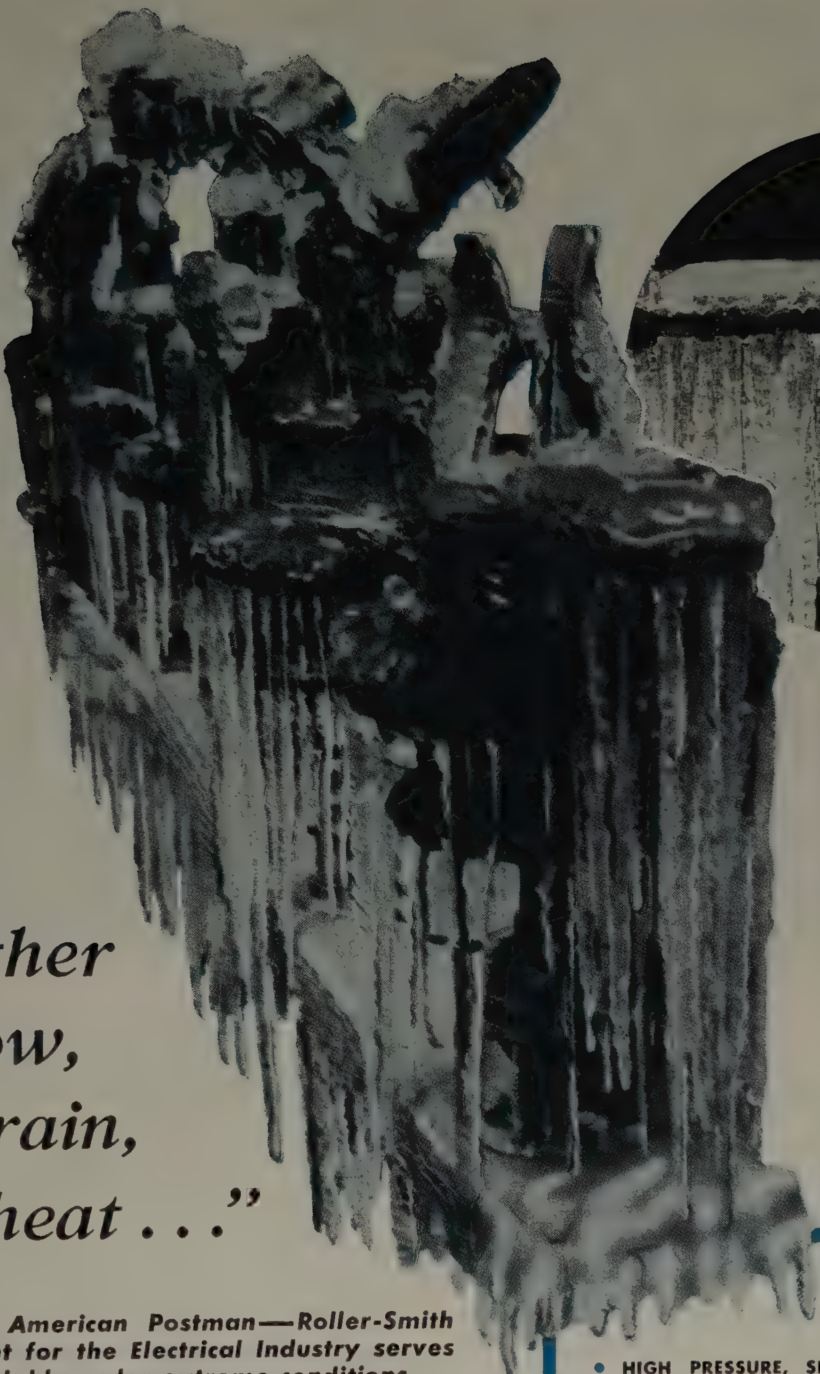
I-T-E HEAVY-DUTY CIRCUIT BREAKERS
Types MT and OH, used for DC sectionalizing in billet mill.

THE SYMBOL OF QUALITY SWITCHGEAR

I-T-E CIRCUIT BREAKER COMPANY

19TH AND HAMILTON STREETS. PHILADELPHIA 30, PA.

SWITCHGEAR PRODUCTS



7.5 KV to 69 KV
400-600-1200 AMPERES
GROUP OPERATED

"Neither snow, nor rain, nor heat . . ."

Like the American Postman—Roller-Smith equipment for the Electrical Industry serves dependably under extreme conditions.

This new Duo-Roll Air Break Disconnect Switch typifies quality of the equipment manufactured by Roller-Smith for the Electrical Industry. Our Products incorporate all the very latest design improvements and offer all the advantages that modern production techniques and strict testing procedures provide. Shown operating under a 1½ inch ice load, this new switch includes the following features which assure the same trouble-free performance you can expect from all Roller-Smith equipment.

- HIGH PRESSURE, SELF-CLEANING SILVER CONTACTS.
- COMPLETELY VISIBLE HINGE AND CLIP CONTACTS.
- "SHUNT-LESS" HINGE CONTACT ALWAYS ENGAGED.
- BUILT TO WITHSTAND HIGH SHORT-CIRCUIT CURRENTS.
- RE-DESIGNED SWITCH BLADE ROTATES TO CRACK ICE LOAD, THEN RAISES TO OPEN CIRCUIT.
- SWITCH BLADE IS "LOCKED" WHEN IN CLOSED POSITION.
- SWITCH MAY BE MOUNTED IN ANY POSITION.
- ADJUSTABLE CLEVIS ASSURES POSITIVE CONTACT AT ALL MOVING PARTS.
- HINGE AND CLIP TERMINAL PADS ARE AT SAME ELEVATION.
- ROTATING INSULATOR BEARINGS ARE SELF-LUBRICATING.

Roller-Smith
CORPORATION
ELECTRICAL SWITCHGEAR
BETHLEHEM, PENNSYLVANIA

Available thru Authorized Wholesalers.
Sales Representatives in all principal Cities.
CANADIAN FOREIGN

This is one of IBM's four laboratories, each providing the most advanced facilities for engineering achievement.

The Engineer's Engineer

In every field of human endeavor there are individuals whose unique abilities—whose important contributions to progress in their own professions and to the happiness, welfare, and prosperity of mankind—have earned them the high esteem of their fellow professionals.

The physician's physician. The author's author. The engineer's engineer.

IBM mechanical and electronic engineers have won the respect of their fellow professionals for their creative thinking, their concern with perfection, their daily standards of performances.

Equipment from the minds and hands of IBM engineers has opened doors to progress for other engineers and scientists. IBM's giant digital computers, for example, are helping petroleum engineers speed their search for oil—aeronautical engineers to conquer time and space—nuclear physicists to harness and apply the atom's power for defense and peace.

On life's broader scene, products of IBM engineering make significant contributions to wealth and well-being. They are helping medical science in its fight against many diseases. They assist our law enforcement agencies in providing greater protection for life and property. They enable business and industry to produce more with less effort and at lower cost for the mutual benefit of maker and user.

Whenever IBM equipment is used—electronic digital computers, electronic and electric accounting machines, electric typewriters or time equipment—the sum of human progress increases.

IBM
TRADE MARK

INTERNATIONAL BUSINESS MACHINES • 590 MADISON AVENUE, NEW YORK 22, N. Y.

Add invisible cops to your police force!

Light and lots of it is the very best deterrent there is to crimes of violence. That is why it is so terribly important that residential streets, as well as boulevards and shopping areas, be adequately and dependably lighted.

Dependable lighting has to be more than good looking, scientifically designed lighting fixtures. The power cables are part of it too. Such cables must be able to withstand winter thaws and freeze-up, as well as summer rains. They must also withstand high summer heat and winter cold.

ANHYDREX Series Street Lighting Cables do this and more. They can be buried in the ground or pulled through ducts. Sometimes they are used inside the lighting standard. But regardless of how they are used, they are dependable. They require no lead sheaths or metallic armor.

Want to know more about these versatile street lighting cables that can be used overhead or underground with or without ducts? Write us directly or contact our representative in your area for more detailed information.

Simplex-ANHYDREX
Series Street Lighting Cables

SIMPLEX WIRE & CABLE CO., 79 Sidney Street, Cambridge 39, Mass.

In Your Distribution Substations

WHAT DOES IT TAKE

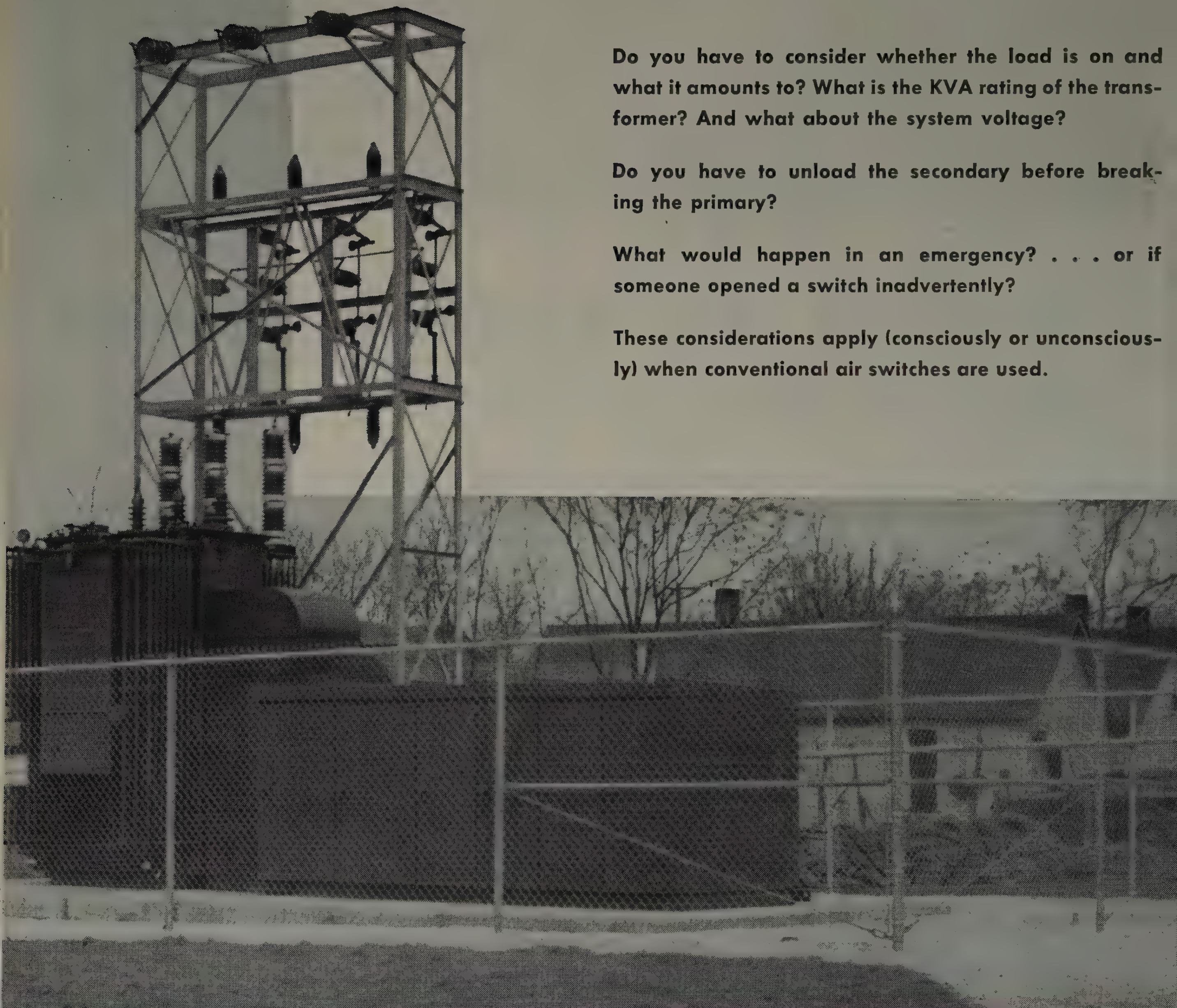
to Switch the Primary?

Do you have to consider whether the load is on and what it amounts to? What is the KVA rating of the transformer? And what about the system voltage?

Do you have to unload the secondary before breaking the primary?

What would happen in an emergency? . . . or if someone opened a switch inadvertently?

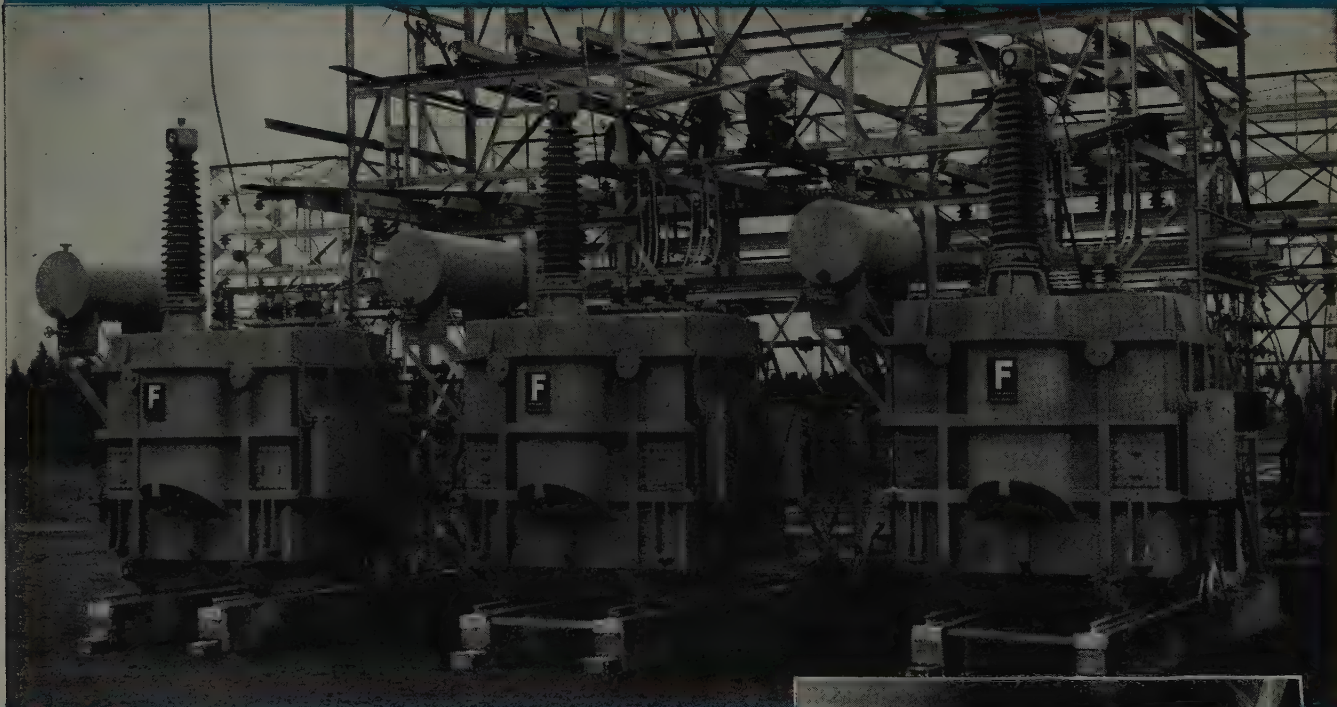
These considerations apply (consciously or unconsciously) when conventional air switches are used.



S P E C I A L I S T S   I N   H I G H - V O L T A G E

FERRANTI TRANSFORMERS

for the Alcan Project, British Columbia, Canada



Four 301,400 volt, 71,000 kVA, single-phase Ferranti generator transformers and three 275,000 volt, 37,000 kVA step-down transformers ordered by by the Aluminum Co. of Canada Ltd. have been supplied for the Alcan Project, Canada. All the transformers are now erected on site at Kemano and Kitimat, British Columbia.

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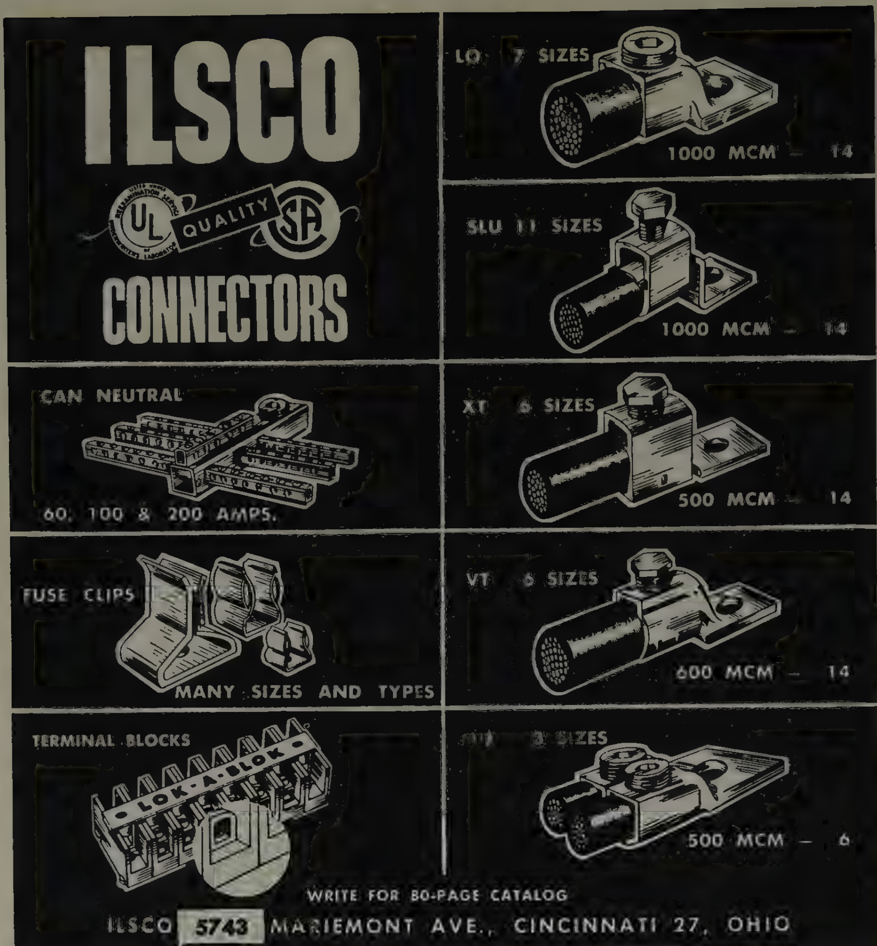
FT151

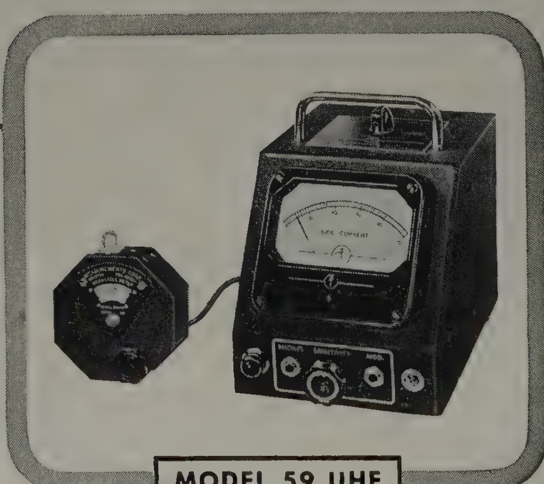


NEW UHF MEGACYCLE METER

With the Widest Frequency Coverage in a Single Band

FEATURES

- Excellent coupling sensitivity.
- Fixed coupling point.
- Small grid current variation over band.
- Calibration point every 10 Mc.
- Uses split-stator tuning condenser with no sliding metal contacts.
- Standard camera socket for tripod fixtures.
- Octagonal case for convenient positioning.
- Useful in television transmitting and receiving equipment.



MODEL 59 UHF

SPECIFICATIONS

FREQUENCY RANGE: 430-940 Mc in a single band
FREQUENCY ACCURACY: ±2% (Individually calibrated)
OUTPUT: CW or 120-cycle modulation
POWER SUPPLY: 117 volts, 60 cycles, 30 watts
DIMENSIONS: Oscillator Unit 4⅝" x 2½"
Power Unit 5⅛" wide x 6⅛" high x 7½" deep

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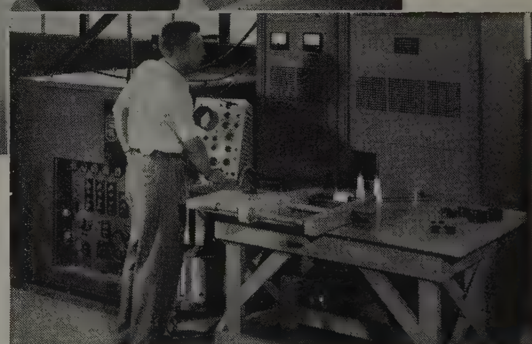

Arnold Pulse Transformer Cores are individually tested under actual pulse conditions

W&D 5238

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"MAGNETIC MATERIALS CATALOG"

General information on all Arnold magnetic materials: permanent magnets, tape-wound and powder cores, types "C" and "E" cut cores, etc.

"ARNOLD SILECTRON CORES"

52 pages of valuable data covering a complete range of core shapes, sizes, tape gauges, etc.

ADDRESS DEPT. EL-12

The inset photograph above illustrates a special Arnold advantage: a 10-megawatt pulse-testing installation which enables us to test-prove pulse cores to an extent unequalled elsewhere in the industry.

For example, Arnold 1 mil Silectron "C" cores—supplied with a guaranteed minimum pulse permeability of 300—are tested at 0.25 microseconds, 1000 pulses per second, at a peak flux density of 2500 gausses. The 2 mil cores, with a guaranteed minimum pulse permeability of 600, receive standard tests at 2 microseconds, 400 pulses per second, at a peak flux density of 10,000 gausses.

The test equipment has a variable range which may enable us to make special tests duplicating the actual operating conditions of the transformer. The pulser permits tests at .05, .25, 2.0 and 10.0 microsecond pulse duration, at repetition rates varying anywhere from 50 to 1000 pulses per second.

This is just another of Arnold's facilities for better service on magnetic materials of all description. ● Let us supply *your* requirements.

THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION

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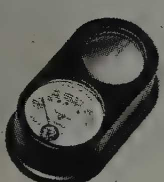
Instruments to • MEASURE • RECORD • CONTROL

Light

WESTON ILLUMINATION METERS



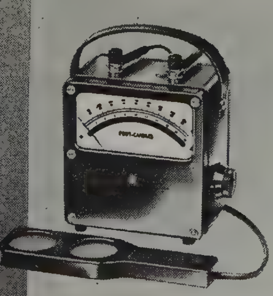
Model 703 Sightmeter or Foot-Candle Meter

For quick measurements in homes, factories, etc. Calibrated in seeing tasks (Sightmeter) and directly in foot-candles. Available with or without VISCOR® and cosine correction filters.

Model 614 Foot-Candle Meter

For commercial lighting surveys. Hinge mounted PHOTRONIC® Cell can be tilted to facilitate use. Measures all types of commercial lighting directly. Wide range of light values.

Model 756 Illumination Meter

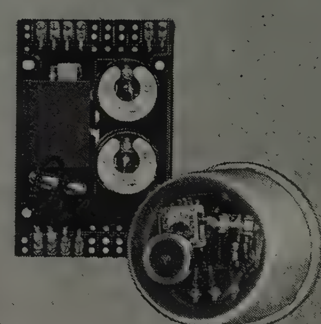


For measurements requiring a high degree of accuracy over broad ranges. Ideal for research and checking other instruments. Corrected for color and Lambert's Cosine Law.

WESTON LIGHT RECORDER

Fluctuations in illumination are accurately charted by the Model 6701 WESTON Light Recorder. PHOTRONIC® photo-electric cell sensing element can be placed wherever convenient. Recorders available with ranges from 20 ft. candles up to as high as 15,000 ft. candles. Ideal for load anticipation studies, determining light output of flares, daylight measurements, and many other industrial applications.

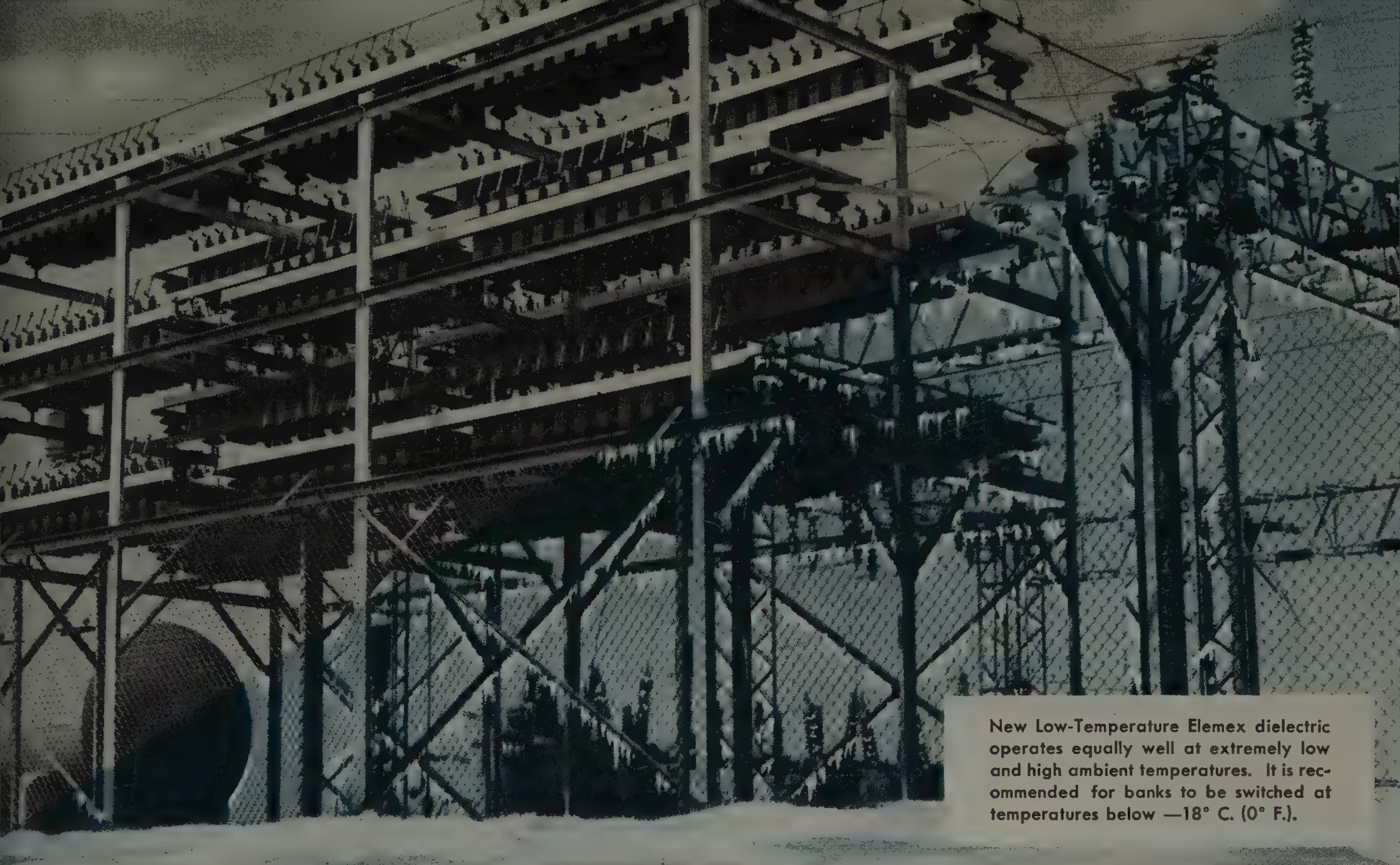
WESTON LIGHT CONTROLS



The Model 1089 plug-in type is the simplest control unit for automatically turning lights "on" and "off" at pre-set levels. Employs no vacuum tubes, resistors or capacitors. Controls either one or two circuits of 3000 watts each at 120 volts a-c. In standard weatherproof watt-hour meter case. The Model 709 (CAA approved) permits quick adjustment of "on" and "off" light values independently, in the field.

For complete information on these WESTON instruments write . . .
WESTON Electrical Instrument Corporation
614 Frelinghuysen Avenue, Newark 5, New Jersey.

WESTON *Instruments*



New Low-Temperature Elemex dielectric operates equally well at extremely low and high ambient temperatures. It is recommended for banks to be switched at temperatures below —18° C. (0° F.).

Switch Capacitors In Any Weather With New Low-Temperature ELEMEX®

When capacitors are continuously energized, they automatically maintain safe internal temperatures. But a switched capacitor that is disconnected from the line during low ambient temperatures is subject to congealing or freezing of the dielectric liquid, depending upon the length of time the capacitor is de-energized.

Energizing Warms Capacitor

If the dielectric reaches temperatures down to —18° C., re-energizing the capacitor will quickly warm the dielectric back to a safe operating temperature. But if the temperature drops below —18° C., and the capacitor is de-energized for some hours, the danger of failure is greatly increased, and the failure of some units in banks switched at these extreme low temperatures may be expected.

Users of standard Elemex capacitors have been especially fortunate in this respect because the flexible tank sides of Elemex capacitors do, to some extent, compensate for the contraction of the liquid at low temperatures and somewhat reduce the extent of voids in the congealed liquid.

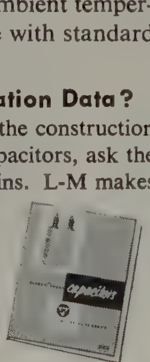
Lower Freezing Point Needed

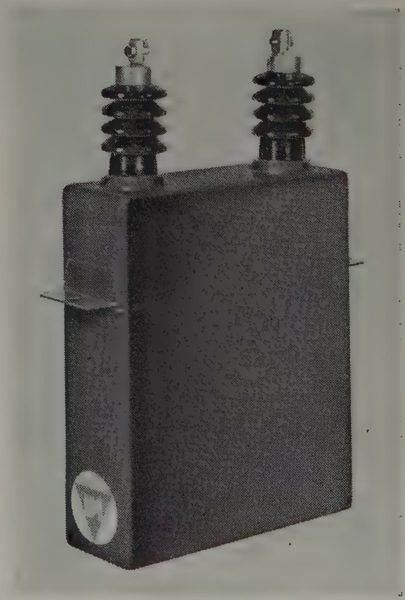
But as switched installations increase, particularly in areas subject to extremely low temperatures, it is desirable to use a dielectric which can stand much lower ambient temperatures without congealing. Therefore capacitors with Low-Temperature Elemex liquid are now supplied upon request, without extra charge.

Low-Temperature Elemex remains liquid at very low temperatures. It can be safely used in switched installations with temperatures as low as —40° C. Also, Low-Temperature Elemex capacitors operate as satisfactorily under higher ambient temperature conditions as do those with standard Elemex.

Want Capacitor Application Data?

For complete information on the construction and application of Elemex Capacitors, ask the L-M Field Engineer for bulletins. L-M makes a wide variety of data available. Or write Line Material Company, Milwaukee 1, Wisconsin (a McGraw Electric Company Division).





Elemex Capacitors offer many other desirable features—solder-sealed bushings with Paragroove connectors; exceptionally low rate of failure. Get details on their construction.

LINE MATERIAL

Elemex® Capacitors

He's using the telephone that lends an extra hand

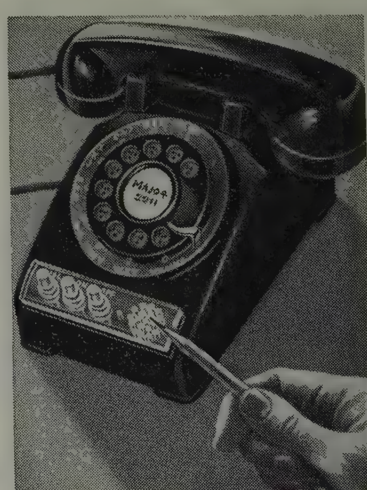
"Sure . . . I'm looking up the figures right now!" From busy executives to clerks, people in business can work more easily and efficiently with Bell's new Distant Talking Telephone. Small white rectangle is the loudspeaker.

For people who want to keep *both* hands free when they telephone, Bell Telephone Laboratories engineers have devised a new telephone with a sensitive microphone in its base.

To use it, simply press a button. The microphone picks up your voice and sends it on its way. Your party's voice comes to you through a small loudspeaker. Both hands are left free.

The volume can be adjusted to suit yourself. If privacy is needed, you simply lift the handset; this shuts off the microphone and loudspeaker and you talk just as you would on a regular telephone.

This new development of Bell Laboratories increases the number of ways your local Bell telephone company can serve in businesses and homes.



Pencil points to microphone in base of new telephone. Left-hand button controls volume, center one turns set "on" and lights up while in use. The third is an "off" button.

Bell Telephone Laboratories

Improving telephone service for America provides careers for creative men in scientific and technical fields.

HOW TRANSITE DUCTS

I. INCREASE CURRENT CARRYING CAPACITY

	TRANSITE INORGANIC DUCTS	ORGANIC DUCTS
1. Total Therm. Res. to Dielectric Loss (thermal ohms)	5.61	6.03
2. Total Therm. Res. to Copper Loss (thermal ohms)	4.21	4.62
3. Temp. rise from Dielectric Loss (°C)	1.9	2.1
4. Allowable rise for Copper Loss (°C)	59.1	58.9
5. Allowable watts for Copper Loss per ft. cable	4.70	4.25
6. Allowable Current—(Amps per cdr)	398	378
7. Allowable Current—(Relative %)	105.1	100

II. YIELD DOLLAR SAVINGS

8. Greater heat carrying ability of Transite (%)	110.6
9. Watts loss per foot at equal currents: Organic Duct	4.25
Transite	3.84
10. Savings in losses with Transite (watts/ft.)	.41
11. Annual dollar savings @ $20/KW per M ft.	$8.20
12. Annual greater charges for Transite per M ft. on basis: 1 ⅓ ducts per cable Diff. mat. cost—$.04/ft. Carry. Chgs.—Int. 6%, Taxes 2 ½% Depr. 1%; Total 9 ½%	$5.06
13. Net annual savings with Transite $ per M ft.	$3.14

CONDITIONS: Cable—3 Cdr. 500 MCM Compact Sector, 175 mils paper, 125 mils lead 15 KV grounded neutral (8th Edition AEIC Spec.) Theoretical Cable Diam.—2.52". Duct—2 x 2 bank, 3 loaded, 4" ducts, 6 ½" spacing, 30" earth cover, 3" Concrete around ducts, Concrete-Soil Resistivity—84 (watt-cm). Load Factor 75%—Loss Factor 62 ½%. Earth ambient 20C.

—and copper losses are reduced . . . current capacity is increased . . . insulation life prolonged

Tests have been made for many years by the Johns-Manville Research Center, to determine how Transite Ducts improve the dissipation of heat by conductors under load. The application of the test results is summarized above.

The figures prove that Transite Ducts will carry heavier current loads than organic ducts when sheath temperatures are the same. The result is a cooler cable under a given load . . . lower I^2R losses . . . longer insulation life from lower operating temperatures.

Transite Ducts offer many other advantages, too. Made of asbestos-cement, they are incombustible, resistant to corrosion, unaffected by electrolysis. When arcing occurs, Transite protects adjacent cables from damage. These durable, light-weight ducts provide complete and permanent cable protection, together with savings on installation and maintenance.

For complete details on these tests and the many advantages of Transite Ducts, write for free copy of Brochure EL-29A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville TRANSITE DUCTS

TRANSITE KORDUCT—for installation in concrete

TRANSITE CONDUIT—for exposed work and installation underground without a concrete encasement

Complete Coverage!

10 cps to 4 mc

-hp- 400D
VACUUM TUBE VOLTMETER

Accurate within 2% to 1 mc

Measures 0.1 millivolt to 300 volts

Reads dbm direct

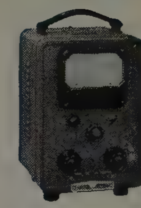
High sensitivity, stability, input impedance

Light, small, portable, dependable

-hp- 400D combines new features never before found in one voltmeter, with time-tested conveniences of the famous *-hp-* 400C.

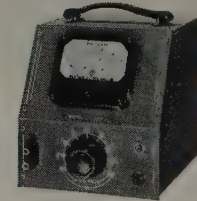
Frequency coverage is extremely broad—10 cps to 4 mc. A new amplifier provides 56 db of feedback (mid-range) for highest stability and freedom from change by external causes. Input impedance is 10 megohms so circuits under test are not loaded. Coupling and by-pass condensers are sealed; electrolytic condensers are long-life type. Construction is highest quality throughout; circuitry is clean, easy to reach. New compact metal case simplifies handling, occupies less bench space. Front tilts upward for convenient reading angle.

Use the new *–hp–* 400D for measuring amplifier gain, network response, output level, hum and noise, power circuit, broadcast high frequency voltages, as an audio level meter, high gain broad band amplifier, null detector, waveform monitor, and coil "Q" meter. $225.00.



–hp– 410B Vacuum Tube Voltmeter

Wide range, flat response ± 1 db, 20 cps to 700 mc. Small, convenient, simple to use. Diode probe places approximately 1.5 μμfd capacity across circuit under test. This plus 10 megohms shunt impedance (high frequency) means circuits are not disturbed, and true voltage reading are assured. Also measures dc voltage to 1,000 volts and resistances to 500 megohms. $245.00.



–hp– 400A Vacuum Tube Voltmeter

Direct voltage readings between 10 cps and 1 mc. 30 millivolts sensitivity full scale; accuracy is ± 3% to 100 kc, ± 5% to 1 mc. Voltage range .005 to 300 volts. Input impedance 1 megohm shunted by 25 μμfd. $185.00.

–hp– 400B Vacuum Tube Voltmeter

For measurements 2 cps to 100 kc. Sensitivity 30 millivolts full scale. Measures voltage .005 to 300 volts, input impedance 9 megohms shunted by 25 μμfd. Accuracy ± 3% to 100 kc. Usable as stabilized amplifier. $195.00.

–hp– 404A Battery-Operated Voltmeter

For general voltage measurements where ac power is not available. Compact, portable, splash-proof, ruggedly built. 2 cps to 50 kc, .0005 to 300 volts, impedance 10 megohms with 20 μμfd shunt. Ideal for remote broadcast, carrier, strain gauge, telemetering, geophysical work; completely hum free measurements. $185.00.

hp®

ELECTRONIC TEST INSTRUMENTS
for speed and accuracy

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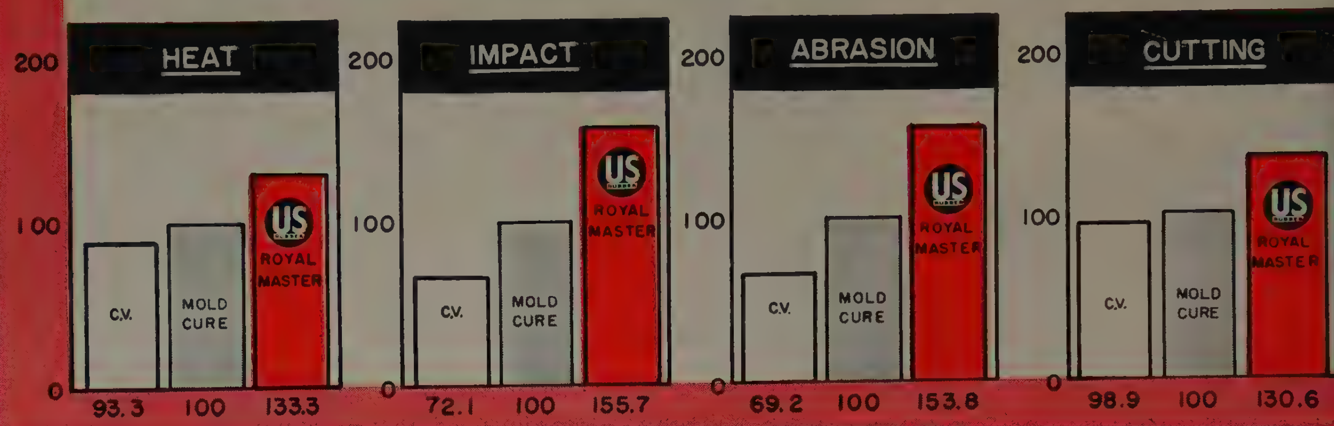
STARTLING

Comparative performance of portable cords related to major life factors.



New U. S. ROYAL MASTER portable cord

PROVES SUPERIOR TO ALL OTHERS IN EVERY SERVICE FACTOR!

Newly developed U. S. Royal Master Cord gives almost twice the service of other molded cords — gives $1.88 value for every cord $1.00!

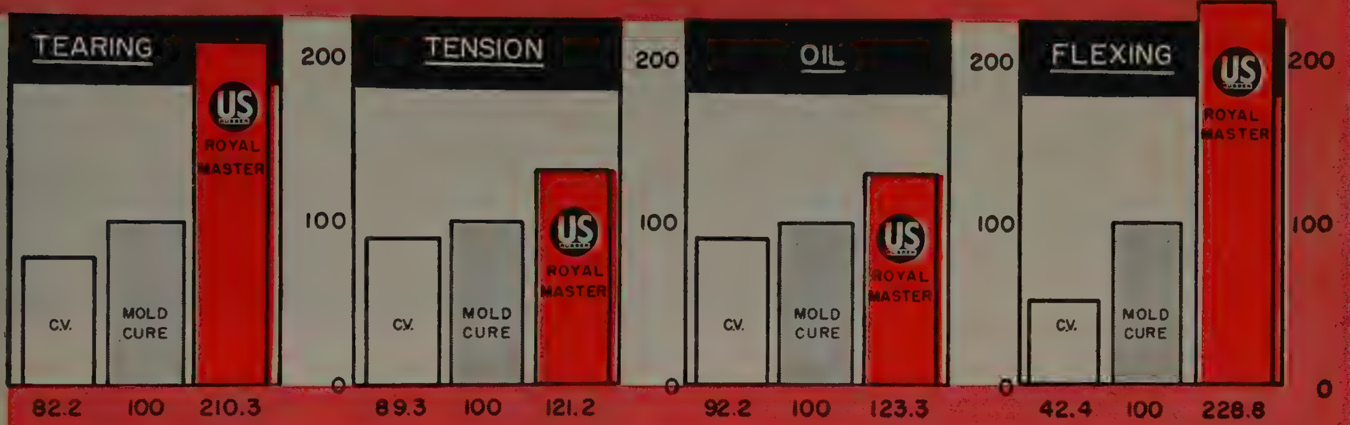
Life factor charts illustrate outstanding superiority of new U. S. Royal Master over the average of both the molded cords and the short-lived continuous vulcanized cords of other makes.

US RUBBER

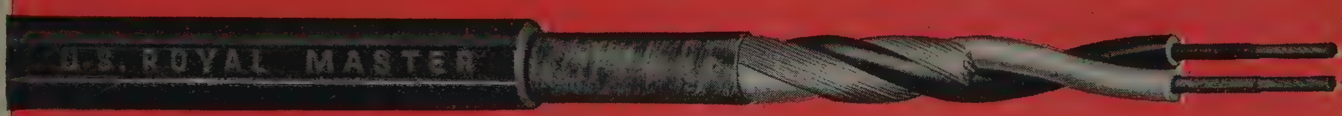
UNITED STATES

ELECTRICAL WIRE & CABLE DEPARTMENT

EVIDENCE!



LOOK FOR THE NAME—U. S. ROYAL MASTER



Approved by Underwriters' Laboratories, Inc.

Cord construction completely reexamined. Over two years ago, U. S. Rubber engineers began a thorough reexamination of electrical cord design and construction. More than a thousand cords, including those of all major competitors as well as our own U. S. Royal Cord, were thoroughly and painstakingly analyzed. Over 10,000 tests were made to determine the principal causes of cord failure.

Every possible life factor was carefully and honestly appraised to find its relation to overall cord service.

With the findings at hand, "U. S." Engineers then drew upon their 64 years of experience in the manufacture of fine quality wire and cable to produce this exceptional new cord.

Every fault uncovered by the exhaustive two-year testing was tackled and solved.

Tested and proved. The new U. S. Royal Master was then tested against all competitive cords—installed in outside plants for final on-the-job corroboration.

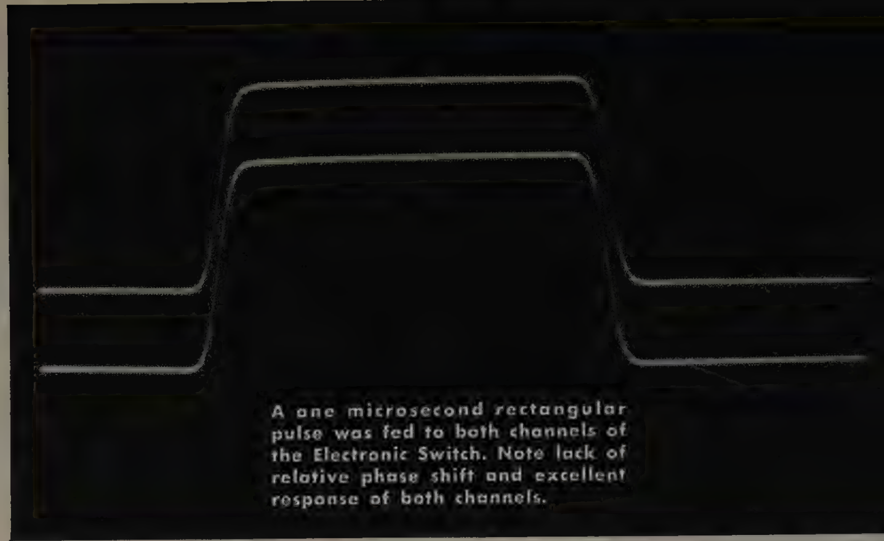
U. S. Royal Master Cord proved itself to be unquestionably the finest cord you can buy! So superior, it gives almost double the service life of the average of competitive molded cords—actually gives you \$1.88 in value for every cord dollar!

Prove for yourself the outstanding superiority of new U. S. Royal Master Portable Cord—in both service life *and* economy! Get in touch with your "U. S." distributor today!

RUBBER COMPANY

ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Convert to Dual Channel Operation in the Range of DC to 15 MC



A one microsecond rectangular pulse was fed to both channels of the Electronic Switch. Note lack of relative phase shift and excellent response of both channels.

...using any Single-Channel Oscillograph with the

NEW DU MONT TYPE 330 ELECTRONIC SWITCH

The new Du Mont Type 330 Electronic Switch is a self-contained accessory for oscillography that permits . . .

1. Converting *any* single-beam oscillograph into a dual-channel instrument.
2. Adding a channel to any multi-channel instrument.
3. As a chopper, converting an a-c oscillograph for d-c measurement.

Within the range of DC to 15 MC, the Type 330 is limited only by the characteristics of the cathode-ray oscillograph being used.

This is the answer to those studies requiring comparison between two or more functions. Maximum time shift between the channels of the Type 330 is within one millimicrosecond. Both channels may be adjusted for unity gain making it a simple matter to superimpose two phenomena for very precise time, phase or amplitude comparison.

Three free-running switching rates, 1KC, 10KC and 100KC, or triggered operation allow selection for best presentation on the cathode-ray oscillograph. The Type 330 can be connected into a test setup or disconnected as the need arises.

MAJOR SPECIFICATIONS

SIGNAL CHANNELS

I. Sinusoidal Frequency Response: with an output load of 60 uuf, either channel, flat to d.c. and down not more than 3 db at 15 mc.

II. Amplifier Rise Time: with external load of 60 uuf, no greater than 0.022 usec.

III. Variable Attenuator: Each channel has two series stepped attenuators with attenuation ratios of 1, 2, 4, 10, 20, 40, 100, 200, and 400; accuracy of attenuators ± 2%.

IV. Output: Level is zero volts d.c. with no signal or positioning voltage; positioning controls provide ±1 volt of d.c. positioning voltage.

SWITCHING

I. Recurrent: Free-running, fixed frequencies of approximately 1 KC, 10 KC and 100 KC; Triggered, rate may be triggered at 0 to 100 KC rates.

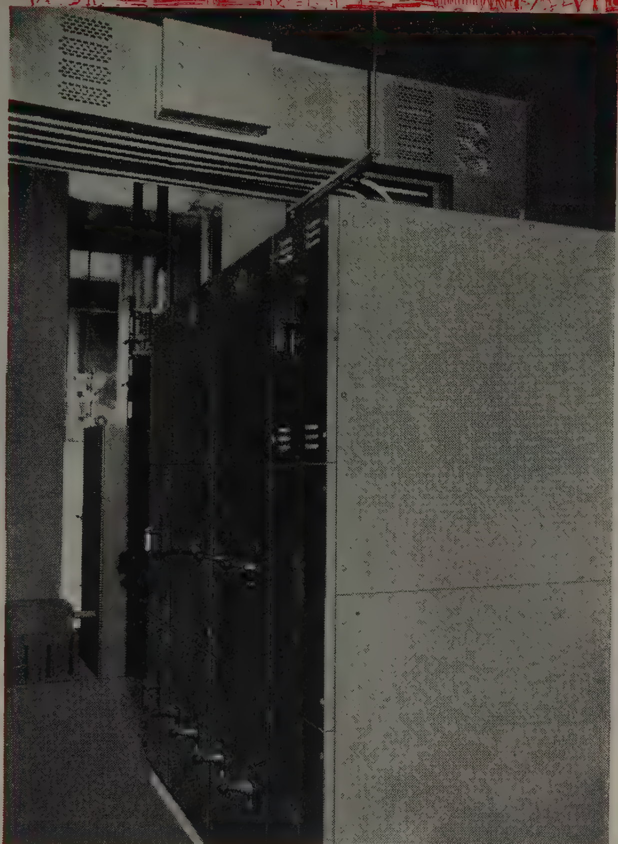
PRICE **$295**

WRITE FOR COMPLETE INFORMATION

DU MONT

ALLEN B. DU MONT LABORATORIES, INC.
INSTRUMENT DIVISION
760 BLOOMFIELD AVENUE • CLIFTON, N. J.

FOR TODAY'S MOST MODERN GRAIN ELEVATOR, FEDERAL PACIFIC EQUIPMENT



At left; top: Federal Pacific Low Impedance Bus Duct feeding from Distribution Switchboard. Bottom: Transformer top outlets with Service Duct to outdoor Switchgear . . . Electrical construction by Fischbach & Moore, Inc., Victory Electric Works, New Orleans. General contractor, Fegles Construction Co., Inc., Minneapolis. Engineers, Jones-Hettelsater Co., Kansas City.

THE RECENTLY COMPLETED New Orleans Public Grain Elevator has an extensive "hazardous location" electrical system for which Federal Pacific has supplied the distribution equipment. From the outdoor substation, Federal Pacific Service Duct carries electric energy into the main building where Low Impedance Duct feeds six distribution center electric rooms on different levels. Throughout the main building, silo storage section, conveyor belt ramps and the handling and ship-loading equipment in buildings along the dock, Federal Pacific Switchgear and Safety Switches help facilitate the handling of an average of seven million bushels of grain per month.

Federal Pacific electrical equipment for light and power is today's top specification. Most of this equipment is economically assembled from standard units . . . and it is designed and engineered for easy installation, complete efficiency and ready adaptability for future changes.

Submit your electrical distribution problems to Federal Pacific for study and suggestions. Write Federal Pacific Electric Company, 50 Paris Street, Newark 1, New Jersey.

FEDERAL PACIFIC ELECTRIC CO.

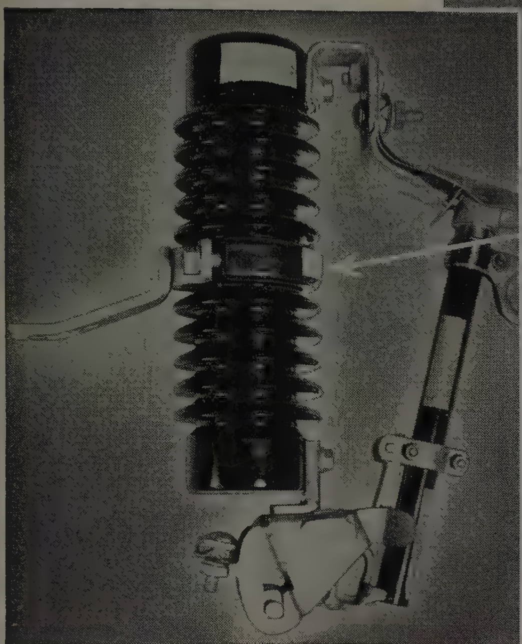
FORMERLY—FEDERAL ELECTRIC PRODUCTS COMPANY AND PACIFIC ELECTRIC MANUFACTURING CORP.

Main Office: 50 PARIS STREET, NEWARK 1, N. J.

Federal Pacific products: Stab-lok Circuit Breakers, Motor Controls, Safety Switches, Service Equipment, Industrial Circuit Breakers, Panelboards, Switchboards, Control Centers, Bus Duct, High voltage circuit breakers and power switches ★ Sales offices in principal cities.

Another new development using

B. F. Goodrich Chemical ***raw materials***



Arrow shows injection molded U-bolt made from Geon rigid vinyl.

B. F. Goodrich Chemical Company does not make this electrical equipment. We supply only the Geon resin for the rigid vinyl plastic.

New cutout "Bird-Proofed" by Geon

ELECTRIC service is occasionally disrupted by birds and small animals that short circuit line equipment. But General Electric has "bird-proofed" their open drop-out fuse cutouts with high impact and high dielectric strength Geon rigid vinyl plastic.

The G. E. cutouts protect equipment and lines from overloads and short circuits and expedite location of storm-damage for repairs. The unit is mounted to its hanger by means of a U-bolt which is insulated with injection molded Geon rigid vinyl. Geon was selected for this application because of its high dielectric and mechanical strengths and excellent weathering properties.

This is another example of Geon's usefulness in the electrical field. Geon vinyl insulating compounds were developed to meet the exacting requirements of the electrical power industry, equipment manufacturers and Underwriters' Laboratories. For information on how Geon can solve your difficult insulating problem, please write Department GS-6, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

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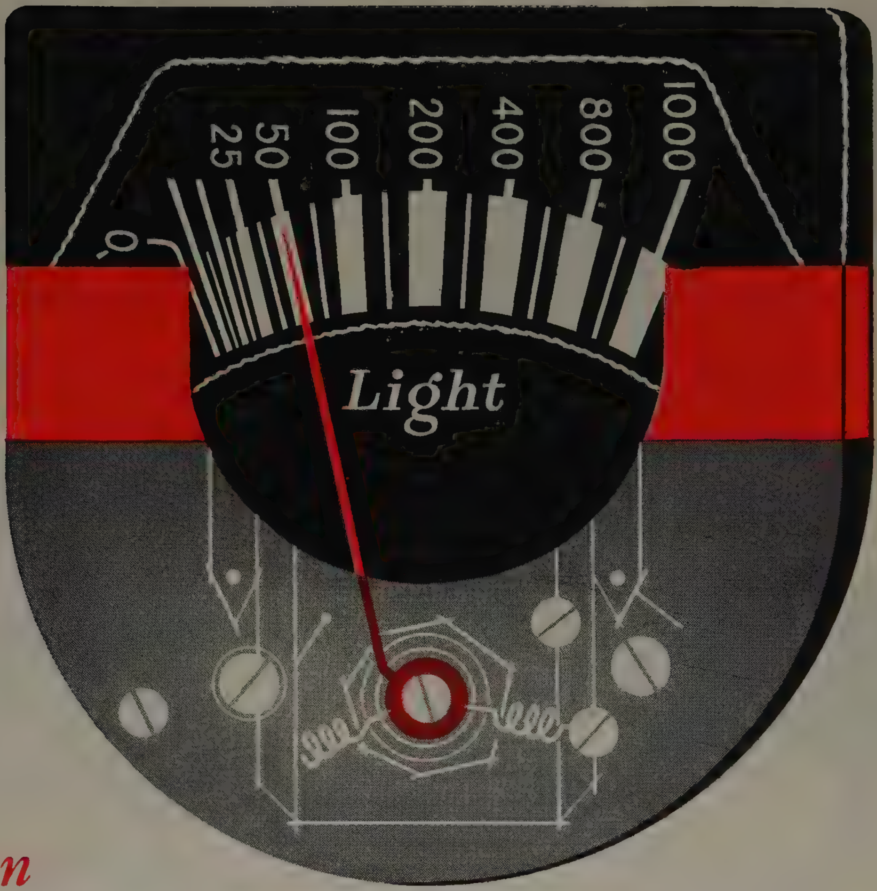

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If you have spare copies of either or both, please write

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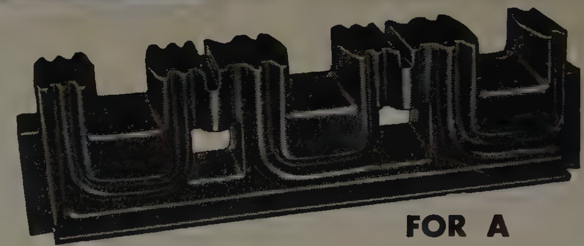

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TRIPLETT
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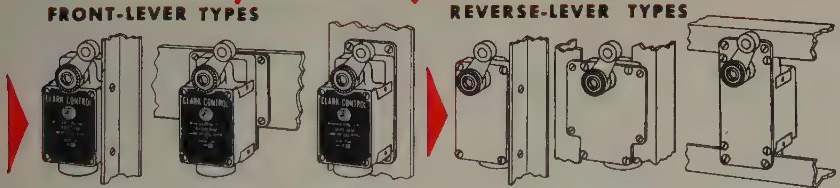
NEW!

CLARK *Type DM* MACHINE LIMIT SWITCH

• This new heavy-duty limit switch is built with a minimum of moving parts, and with emphasis on simplicity of construction. The primary objective in its design is to provide dependable, accurate, trouble-free operation for a long life. All latch and trip-bearing surfaces are nylon to steel for minimum wear. All springs are in compression for greatest safety—they cannot be overloaded. This and other features make the switch as nearly fail-safe as possible.

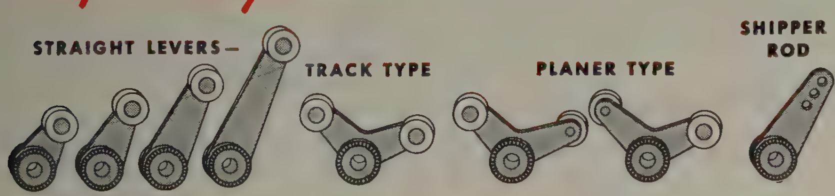
Mounting Arrangements



FRONT-LEVER TYPES: Side Mounted · Horizontal Flange Plate · Vertical Flange Plate

REVERSE-LEVER TYPES: Side Mounted · Horizontal Flange Plate · Vertical Flange Plate

Operating Levers



STRAIGHT LEVERS— 1 in. · 1½ in. · 2 in. · 3 in.

TRACK TYPE

PLANER TYPE No. 1 · No. 2

SHIPPER ROD

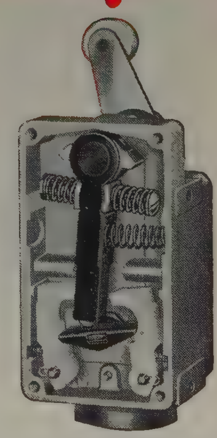
Nylon roller cushions impact, has low friction coefficient and long wearing qualities.

Reversible operating lever. Simple screw driver adjustment for reversing or positioning.

Heavy molded insulating chamber surrounds all live parts and provides ample wiring space for four No. 12 wires with Stakon connectors.

Areas subjected to arcing are protected by glass-melamine plates.

Electrical and mechanical sides of switch are completely isolated.



Nema Type 5 dust-tight, oil-tight enclosure of heavy die-cast construction.

Double-concentric overtravel springs in compression for fail-safe operation.

Return spring is in compression. Can be changed without tools to either side of arm, or removed for maintained contact.

Spring-loaded latches are nylon for low friction and long life.

Choice of ½″ or ¾″ conduit opening.

Write for Bulletin 102DM

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Engineered Electrical Control

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THESE ARE CRANE INSULATORS

These are, left to right . . . a unit for supporting a rectangular conductor which is part of the control circuit on a crane . . . a pivot, or bearing insulator, for a pickup shoe . . . and a crane rail support. Metal parts are malleable iron, hot dip galvanized, with galvanized steel nuts and bolts. Porcelain is Lapp vacuum-process ware, chocolate-brown glazed; each porcelain body, of which you see the shell, has an integral head similar to that of a suspension insulator.

These are regularly-catalogued items, and appear in the "Industrial" section of your Lapp catalog.

But until Lapp made such units, this requirement was largely handled by insulators of organic material. Under humidity and the dirt conditions always present in industrial plants, leakage current flow would track and short-out insulators. Lapp's contribution to such service is insulators stronger, of longer life, more nearly self-cleaning, and of a material which permits leakage flow without deterioration.

Lapp has wide experience in working with engineers in the solution of all sorts of electrical-and-mechanical problems. To such a cooperative effort, we bring a keen willingness to tackle a tough problem, an ability to produce complicated or difficult ceramic pieces on a basis that makes them practical as to cost, and an ability to combine porcelain and metal parts to achieve strong, permanent, secure designs.

Perhaps you have no such problems, and so no interest in this story? Or perhaps all you have to worry about is a system involving some thousands of insulators, and equipment with insulating components (which, simple as they may look, are, in many cases, among the most complicated porcelain parts ever made). In which case, there ought to be a lot of interest on your part in insulators, and insulating components, which give an extra margin of operating security, long life and low upkeep. The kind Lapp makes.

Lapp Insulator Co., Inc., Le Roy, N. Y.

Lapp

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The *Vari-Amp* feature also permits retaining full 10% buck even at increased current ratings. Then the regulator operates at heavier loads in a "raise" direction . . . at lighter loads in a "lower" direction.

In addition to those important multiple ratings, you get low exciting current, low maintenance, and close, accurate control with Allis-Chalmers single-phase power regulators. Get the full story. Contact your nearby Allis-Chalmers district office or write Allis-Chalmers, Milwaukee 1, Wisconsin for Bulletin 01B6065C.

A-4461

Vari-Amp feature makes possible these additional ratings

Volts	Kva of Regulator	±10%	±8¾%	±7½%	±6¼%	±5%
2400	12	50 amp	57 amp	66.5 amp	80 amp	100 amp
	24	100	114	133	160	200
	36	150	171	200	240	300
	48	200	229	267	320	400
	60	250	286	334	400	
	72	300	343	400		
	96	400				
4800	12	25	28.6	33.3	40	50
	24	50	57	66.5	80	100
	36	75	85.7	100	120	150
	48	100	114	133	160	200
	60	125	143	167	200	250
	72	150	171	200	240	300
	96	200	229	267	320	400
	120	250	286	334	400	
	167	348	397			
6900	17.3	25	28.6	33.3	40	50
	34.5	50	57	66.5	80	100
	69	100	114	133	160	200

Extra Short-Circuit Capacity Available

25 times normal short-circuit capacity available with each of these current ratings gives short-circuit capacities as high as 10,000 amperes on smaller units.

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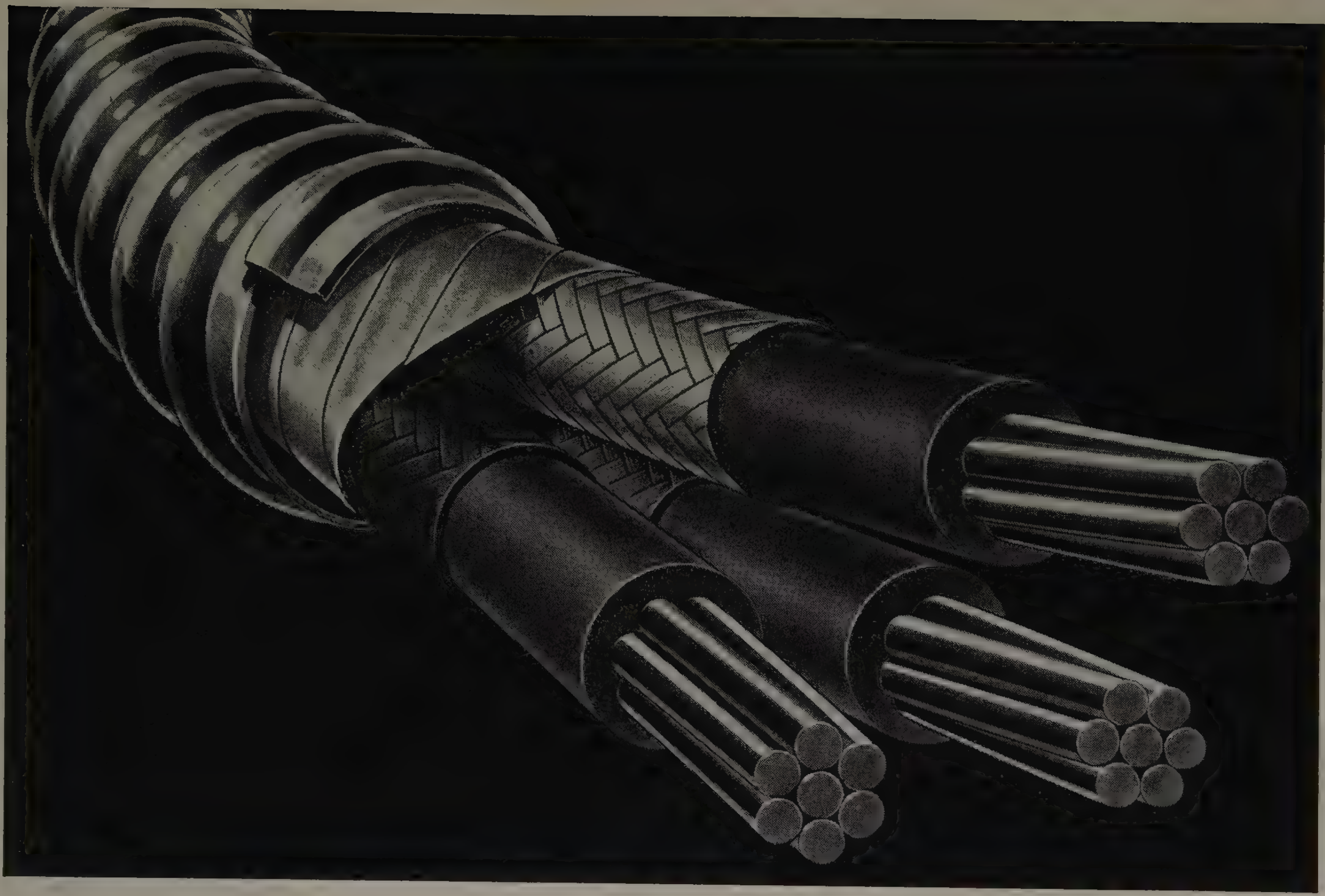
Originators of 5/8% Step Regulation



What goes into a G-E Silicone-rubber Cable?

Silicone-rubber insulated cable being subjected to 1400°F flame for 24 hours in laboratory tests. Superior materials and rigid testing go into each G-E cable.

How can G-E silicone-rubber insulated cable keep control circuits in operation—although engulfed in flame? Why can this cable operate at temperatures up to 257°F? What gives it the moisture resistance of the best grades of rubber? In short, what makes it an outstanding cable for vital control circuits, for boiler room installations, and for high-temperature processing operations?

The answers to all these questions are the unique properties of the special silicone-rubber insulation—and each vital property has a history of G-E research, development engineering, and testing. Flame tests at 1400°F proved that this new insulation would remain nonconducting even when completely oxidized. Accelerated-aging tests proved that the cable would dependably withstand continuous ambient or conductor temperatures up to 257°F. Silicone rubber was compounded in many different ways and proportions to produce a cable that would retain its electrical and physical properties through prolonged water-immersion tests—and that could be handled and terminated as easily as an ordinary rubber-insulated cable.

When you specify G-E silicone-rubber insulated cable or any G-E cable you can be sure that the research, knowledge and equipment of the entire General Electric Company have been combined to produce the best possible product. For more information write Section W137-616, Construction Materials Division, General Electric Company, Bridgeport 2, Connecticut.

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GENERAL ELECTRIC

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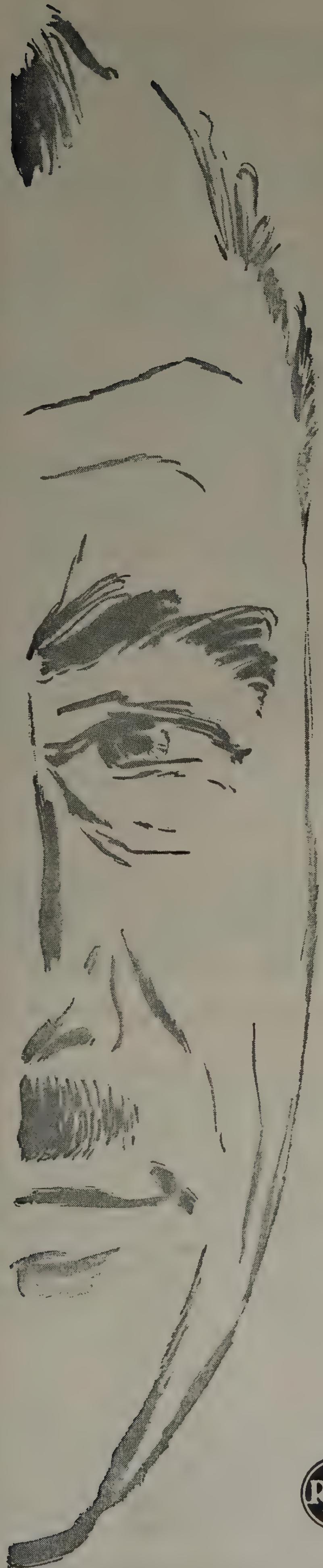

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temporary services (about one year) of experienced technician to initiate dispatching service and train local personnel in its operation and maintenance. System is combination thermal and hydro with transmission up to 132 kv. Excellent opportunity for active retired experienced chief load dispatcher. Reply giving education, experience and personal particulars. Box 158.

ELECTRICAL ENGINEER—JUNIOR OR ASSISTANT DISTRIBUTION ENGINEER. Technical graduate with at least 3 years field experience operating utility company. Permanent position with long established consulting organization New York. Some travel Latin America necessary in future. Knowledge of Spanish or Portuguese useful. Salary commensurate with experience. Reply stating age, education, experience and personal particulars. Box 189.

ELECTRONIC RESEARCH AND DEVELOPMENT positions are available to men with intelligence, imagination, and the desire to produce significant work. Our firm is devoted entirely to research and development, numbers about 1000, and is owned by one of the nation's leading universities. Our salary and benefit programs are competitive with industry. Almost every branch of electronics is covered in our program, and internal funds are available for research on promising individual ideas. Additional information on current openings will be sent upon request. Cornell Aeronautical Laboratory, Inc., Buffalo 21, New York.

MANAGER FOR RURAL TELEPHONE SYSTEM, located in Northern Montana. State age, experience and expected salary in first letter. Write R. O. McPhillips, Coordinator, Northern Telephone Association, Shelby, Montana.

ASSISTANT OR ASSOCIATE PROFESSOR needed by September, 1955, at an expanding midwestern technical college for instruction in electronics, communications and servomechanisms. MSEE Degree and teaching or research experience are minimum requirements. Salary open. Send resume to Fournier Institute of Technology, Lemont, Illinois.

STEAM PLANT DESIGNER—Either EE or ME qualified to assume lead in either electrical or mechanical sections or both of design on addition to steam electric station by long established firm of independent engineers. Will require locating in Mississippi, Nebraska, Florida, Colorado or Washington states. Starting salary $6,000–$7,000 with excellent advance prospects depending upon demonstration of technical capabilities and personal qualities and characteristics. Reply in confidence giving details of personal and professional background. Box 226.

ELECTRICAL ENGINEER—South American subsidiary of large U. S. industrial corporation is seeking a high calibre man with broad experience in power generation, low voltage transmission, distribution, and industrial applications and control. Applicant should be familiar with operating and maintenance problems. Ability to speak Spanish desirable but not essential. Submit resume of experience, personal data. Indicate availability and salary required. Box 227.

ELECTRONIC DEVELOPMENT ENGINEER needed by Ohio manufacturer to assume responsibility for the design and development of electronic equipment associated with high speed printing systems for special applications. Must have had at least 5 years design and development experience on equipment involving pulse techniques and synchronization problems. Starting salary $7500 per year. Allowance for moving expense. Replies held in confidence. Submit resume to Box 228.

NOTE: Closing date for material to be set in the classified advertising column, as well as cancellations for running ads, must be received not later than the first of the month preceding issue; i.e., July first for August issue.

WANTED: ELECTRICAL OR MECHANICAL ENGINEER for design and development of temperature controls. Attractive permanent position available in new research laboratory of leading producer of controls for home and industry; location near Pittsburgh. Engineers with superior ability and successful experience (approximately ten years) in design of controls, switches, or other small and medium-size mechanisms are invited to send a brief resume. Applicants for this position must be qualified to assume responsibility for designing, testing and evaluating controls. Box 229.

COIL AND INSULATION ENGINEER. Position in our large Motor Engineering Division offers an excellent opportunity for future advancement to a qualified applicant with experience in coil design and insulation systems for electrical motors and generators. Will handle problem of new materials, their specifications, insulation processes and shop procedures. Salary open. Location; Northeast Ohio. Box 231.

ENGINEERS—College positions, February and September vacancies. All sections U.S., all fields of engineering. Openings for B.S., M.S. and Ph.D.'s. Excellent salaries. Send pictures and qualifications to Cline Teachers Agency, Box 607, East Lansing, Michigan.

Positions Wanted

ELECTRICAL ENGINEER, BEE, PE, 40, seeks work with supervisory responsibility in design and application of apparatus and control circuits. Extensive experience in same type of work in liquid metal systems for heat transfer, and in steel and rubber industries. Box 215.

ELECTRICAL POWER ENGINEER, doctorate, wide scientific background, 16 years experience power application and distribution problems in steel, electrochemical and chemical factories, familiar corresponding instruments and machinery, high voltage networks calculations and stability studies, testing electrical materials, expert engineer in foreign service, perfect German, Italian, French, age 46, married, desires position in Eastern or Midwestern States. Box 221.

AVAILABLE FOR BRAZIL, ELECTRICAL ENGINEER with 16 years' experience in large American firm abroad, last 4 years in Rio de Janeiro. Good organizer, speaks fluent Portuguese. Box 232.

PROFESSIONAL ENGINEER—Design, Field and Administrative experience in Aircraft and Electronics industries. Desires responsible position with small or medium size company. Box 233.

PROFESSIONAL ENGINEER, B.C.E., Associate Member AIEE, Junior Member ASCE, Member NSPE, with 6 years of responsible transmission line design experience, presently employed, interested in responsible position with consulting firm. Box 234.

ELECTRONIC ENGINEER—29, BEE, MBA; receive LLB June 1955, 3 years experience. Seeks stimulating position utilizing background, N Y Metropolitan area. Box 235.

EDITOR OR EDITORIAL ASSISTANT. 11 years combined engineering and managing editorship experience. Want position in East with up-to-date firm requiring experienced administration of editing, writing, in field of management reports, research reports, brochures, technical publicity promotion. Box 236.

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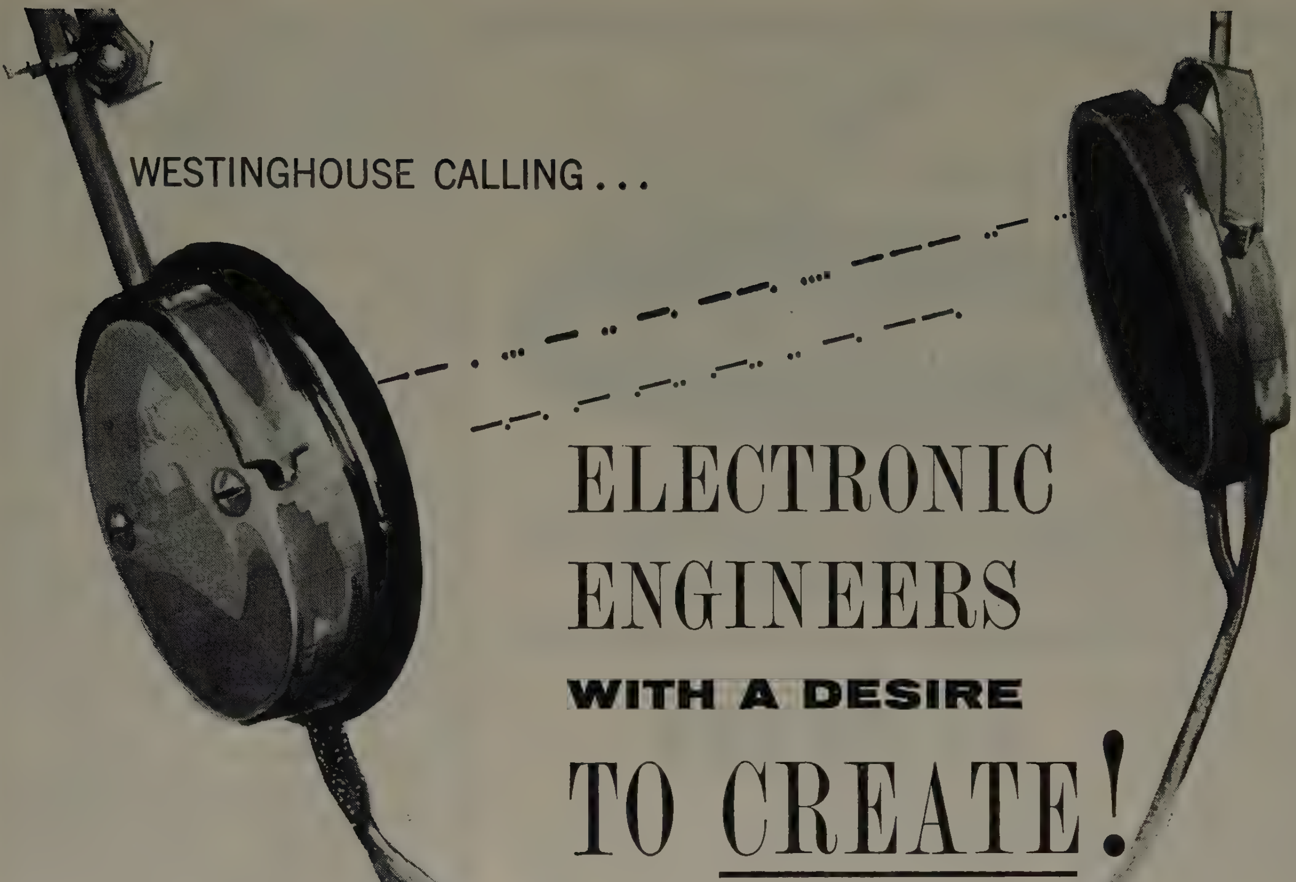

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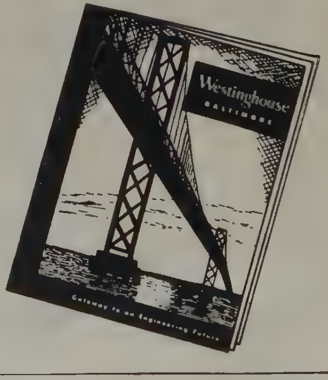

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• **To commemorate the name of its founder,** the company has established the Hannibal C. Ford Fellowship for advanced study in engineering at Cornell where Mr. Ford was graduated 50 years ago.

➡ Each year Ford Instrument Company is offering positions to young engineers whose abilities qualify them to work on the exciting and important projects the company has contracted to develop. If you want to know more about Ford Instrument Company write for illustrated brochure.

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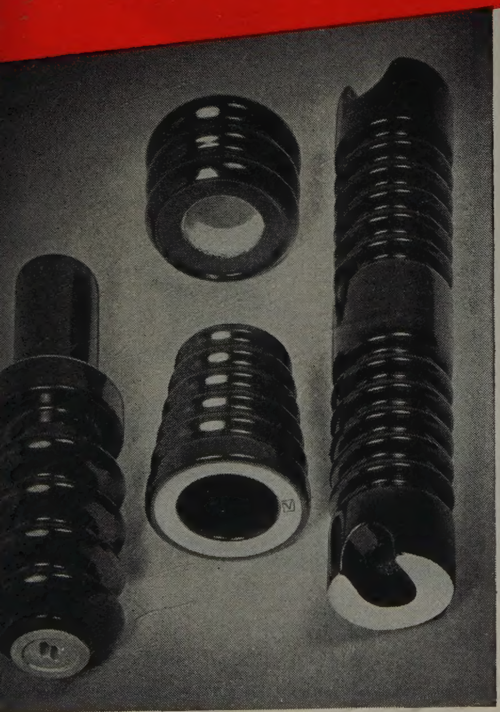

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